VOL. 21, NO. 3 September, 1946

THE QUARTERLY REVIEW of BIOLOGY

PREDATION AND VERTEBRATE POPULATIONS

(CONCLUDED)

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PREDATION AND POPULATIONS OF LOWER VERTEBRATES

Basic Mechanisms

LOWER vertebrates may thrive in given habitats or they may not; they may be subject to heavy losses from emergencies or from predation or from these combined; but, under conditions of fair environmental stability, they may distinctly show levelling-off and counterbalancing with increased crowding.

Noble and Bradley (1933) referred to many lizards as living "in circumscribed territories which the males defend during the breeding season." In his study of the social hierarchy of *Anolis carolinensis*, Evans (1936) reported that the "urge to acquire and to hold a certain territory is very marked." Breder (1936), in his account of the reproductive behavior of sunfishes (Centrarchidae), cited one of Evans' writings on *Anolis* as containing "items that suggest that the territorial holdings of nesting fishes may involve similar elements." Noble's (1938) review of sexual selection in fishes not only described behavior of typically territorial species but also of school breeders, in some of which "the males as a group select suitable spawning areas and wait *en masse* for the females to arrive." In the lake lamprey (*Petromyzon marinus unicolor*), "at the base of the vertebrate series, it is the presence of male pugnacity and the lack of aggregation drive which has marked out discrete breeding territories... The struggle for territory is, however, not keen..."

Territoriality in lizards and fishes may still allow great abundance of individuals. Barbour (1926: 7) classed *Anolis* in the Bahamas as among "the most teeming reptiles on the globe"; and, despite the restrictive effect of over-small territories on breeding of sticklebacks (*Gasterosteus aculeatus*) (ter Pelkwijk und Tinbergen, 1937), these fishes can attain high densities locally.

Whether or not lower vertebrates have thresholds of security at all like those of muskrats and bobwhites, they derive clear advantages from superior habitats. Efforts to improve lakes for certain species of fishes by means of brushy installations and other mechanical refuges have been successful (Hubbs and Eschmeyer, 1938: 203–206). Concerning the pigmy sunfish (*Elassoma zonatum*) in natural habitat at Mound, Louisiana: "It is true that should this fish wander from its home of thick submerged plant growth, it would quickly find numerous enemies among the fish. In its own environment, however, fish enemies are very few" (Barney and Anson, 1920).

Herrington (1944), from statistics on the haddock (*Melanogrammus aeglefinus*) of the North American Atlantic Coast, saw that: "On the average the largest adult stocks have resulted in the smallest production of young, the intermediate stocks have been most successful in producing young, while the small adult stocks have been less successful than the intermediate, but have done much better than the very large stocks... Since we have no records of cannibalism among haddock, it appears that the limiting factor in the survival of any year class of young haddock is food competition... The areas in which the

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most important nursery grounds are found seem to be less attractive to the old fish and they are overrun only in years when the population density on the preferred grounds exerts sufficient pressure to force extension of the feeding range." In the North Pacific, the data from over-exploited halibut (*Hippoglossus hippoglossus*) fisheries indicate a partially compensating replacement (Babcock, Found, Freeman, and O'Malley, 1930).

The rates of increase of the haddock for the 1916–19 and 1926–29 periods (see Herrington's fig. 5, covering 1912–38) were depressed too much in relation to adult densities to look explainable in terms of competition alone. Rather, one may think of the synchrony between the groups of unproductive years and the "10-year game cycles" in the north-central and northeastern regions—taking into account the possibility of cyclic effects, 1936–38, having been obscured by the consistently low status of the adult haddock populations after 1929.

The literature affords what may be inklings of synchronized depression phases in both inland and marine fishes of North America. For examples, the shiner (*Notropis v. volucellus*) population of an Indiana lake studied by Black (1945) "in 1937 was decidedly less than in 1936," when it "was but a small fraction of the number present in 1935 and previous years"; and a minimum sardine (*Sardinops caerulea*) catch was taken in California waters in 1937–38 (Silliman and Clark, 1945). The massive statistics on fish catches in reports of public agencies such as the U. S. Bureau of Fisheries could probably be made to yield more complete information on cyclic depressions (contrasted with mere fluctuations in catches) if reviewed in detail and resynthesized, but such a study I am not in a position to undertake.

Cagle's (1942) work on turtle populations of five species in southern Illinois gave "no evidence that any of these species compete directly. Perhaps the differences in percentage composition can best be explained in terms of degree of satisfactoriness of habitat." This is of course reminiscent of most higher vertebrates living in native association, and conceivably might apply to many lower vertebrates. Nevertheless, among the lower, we may often detect the workings of interspecific as well as intraspecific competition.

On the basis of fish studies in Illinois and Michigan, Hubbs and Eschmeyer (1938: 161) expressed the "biological principle that a lake (unless improved in food production) continuously feeds and otherwise supports only a certain number of pounds of living fish, and that as the poundage of any one species (or age group) increases, the poundage of a competing species (or age group) decreases. It has been a general observation that when pike fishing in a lake declines, bass fishing often improves (and *vice versa*), presumably more because these species are competing for the same food supplies than because either of the species is feeding on the other." Eddy and Carlander (1940), after citing examples of similar balancing in Minnesota waters, gave "one further bit of evidence that the population density is an important factor in controlling the growth rate of fishes. It has often been noted that when a species is successfully introduced into a new habitat, the growth is unusually good. This is largely because of the small number of individuals present and the lack of competition within the species."

Summarizing factors affecting fish growth, Van Oosten (1944) also brought out the "possibility that a lack of space in itself may inhibit growth independently of any competition for food . . . one of the best discussions available on the subject . . . [having been] published more than 60 years ago (Semper, 1880)." Warfel and Merriman (1944: 83–86) observed that collective densities of several species of shore zone fishes of the Connecticut Coast attained, and then declined from, about the same maximum levels three times from July to November, 1942; two fishes (*Menidia m. notata* and *Brevoortia tyrannus*) were most abundant during the three maxima, but neither was dominant throughout.

Cannibalism involving the young operates essentially as does interspecific predation in amphibians (Noble, 1931; A. H. Wright, 1932; Rostrand, 1934; Holmes, 1935; Bragg, 1944–45); and, in the fishes, like relationships are manifest. Breder and Coates (1932) found in their experimental manipulations of *Lebistes* that infanticide "is directly proportional to population concentration," and that overpopulations descended, and underpopulations ascended, to stabilize at about the same figures. Management measures taking advantage of cannibalism in the rainbow trout (*Salmo gairdnerii*) in British Columbia have been suggested by Mottley (1940; 1941) in order to control the numbers of these fishes reaching "legal size." The experiments of Needham and Slater (1944) in California demonstrated

the ineffectuality of planting fingerling rainbow and brown trouts (*S. trutta*) "in streams containing numerous wild trout, since competition and predation prevent any significant survival"; overwintering losses of the brown trout, 1939–43, were much in proportion to numbers, regardless of fish sizes (Needham, Moffet, and Slater, 1945).

The salmonids not only furnish other good examples of intraspecific balancing linked with food and numbers of individuals of cannibalistic sizes (Fry, 1939), but also some of the best examples relating to the population effect of interspecific predation.

Influence of Interspecific Predation on Fish Populations

Quantitative data on sockeye salmon (*Oncorhynchus nerka*) in Cultus Lake, British Columbia, show that, in years when the populations of yearlings migrating from the lake were very large, the sizes were "relatively small but . . . in years of moderate to small runs" there was no simple relationship between size of the run and size of the migrants (Ricker, 1937). Predation by other species of fishes showed a definite relationship to the abundance of the young salmon (Ricker, 1941). The positive correlation found between the experimental reduction of salmon enemies and increased survival rate of the salmon (Foerster and Ricker, 1941) gives weight to conclusions as to population effects: about three times as many young lived to go to sea, the survival averages rising from 3.13 to 9.95 per cent.

Investigations of the Atlantic salmon (*Salmo salar*) in eastern Canada have yielded some very interesting though difficulty appraisable data. Huntsman (1931) traced through gross fluctuations in annual catches a scarcity, of unknown cause, time, and manner of action, recurring at average intervals of 9.6 years, superimposed in turn upon fluctuations due to human exploitation and lesser periodicities resulting from competition between different age classes. He later (1938) concluded that a cause of the 9.6-year periodic scarcity was fluctuation in rainfall affecting stream flows and, indirectly, the vulnerability of young salmon to fish-eating birds.

White's (1937; 1939) observations and experiments relating to fish-eating birds, which furnished Huntsman with much of the basis for his deductions, indicate what could hardly be other than population effect of predation by kingfishers (*Megaceric alcyon*) and mergansers (*Mergus* spp.) during times when the stream waters were low and clear. Conspicuously higher densities of the fishes were able to maintain themselves in parts of the streams where the birds were killed or kept away through human activities; and, on parts well hunted over by the birds, the surviving fishes were chiefly restricted to habitats conferring good natural protection.

Huntsman (1941) mentioned increased cannibalism as a result of the larger young salmon becoming very numerous. There was increased predation by the trout, *Salvelinus fontinalis*, which, according to White (1939), was "a great destroyer of young salmon" and a species benefitting more than the salmon from artificial reduction in the numbers of fish-eating birds. Though most possibilities of intercompensatory trends in loss and survival rates of the salmon remain unexplored, it would not seem likely that intercompensations could have been sufficiently influential to have offset the lessened predation by birds. Not only was the reduction in birds in 1937 followed by more than double the numbers of young salmon descending the test stream at appropriate times, but the 1940 catches of adults corresponding to the young artificially protected in 1937 also were high in comparison with the catches from populations that had not been protected.

Huntsman's fig. 2 in his 1938 paper, depicting variations in the summer rainfall and in the Miramichi salmon catches, is subject, I think, to interpretations other than those given. By this, I do not challenge the conclusion that dry summers, by increasing losses of young salmon during their stream life, have a pronounced influence on the number of adults of corresponding age classes later taken by fishermen. But, to my eyes, the degree of correlation shown merely reflects emergency fluctuations superimposed upon what may be termed the basic periodic cycle, which Huntsman recognized as "in close agreement with a periodicity in abundance of various fur-bearing animals (snowshoe rabbit, lynx, marten, etc.) . . . [and] ruffed grouse of the interior . . ." Demonstrating that the above cycle is caused by the weather is quite another matter.

In his researches, Huntsman (1941) had been looking for a "factor operating unfavorably 'near the time of the descent of the Salmon from the river as smolts'," and he used three years as the interval between operation of this factor and the time "when the affected fish had reached the

size for capture." Applying this criterion in lining up the rainfall and the course of the Miramichi salmon fishery (Huntsman, 1938), we may not only link salmon depressions with dry summers but also with wet summers, and some dry summers were not followed at proper intervals by salmon depression.

Comparing the salmon data with the over-all fluctuations of North American grouse and rabbits for the first three decades after 1900 (Leopold, 1933: 65), we may see that the periods of depression for 1907–08 and 1916–17 were in fair agreement for the terrestrial and aquatic species, alike. The main salmon depression of the third decade traces back to 1925, a year or two earlier than the low of the cycle for grouse and rabbits in most areas for which reports are available. The next year of apparently synchronized depression of salmon (Huntsman, 1941) and land animals came in 1936—assuredly a drought year but, for many higher vertebrates in the north-central and northeastern United States, also one of the periods of exceptionally depressed rates of increase in relation to density that patently reflected more than drought (see Errington, 1945, and the first part of this review). And the increased rainfall shown for 1917 (Huntsman, 1938) would imply that more than drought operated to bring about the very low Miramichi salmon catch of 1920; the summer of 1916 was dry, although not as dry as the summers of 1919, 1923, 1926, 1929, and 1933, after which the catches were not depressed nearly as much as the catch of 1920. The 1936 catch was high, yet 1933 had the lowest July-August rainfall recorded in the period under consideration. If the 1919–20 depressed catch be attributed to the four consecutive dry summers, 1913–16, then the even more uniformly dry 1923–26 period would seem to show a great deal less correlation, in that the corresponding catches averaged almost twice those for 1919–20.

The Miramichi statistics show many low catches that were associated with neither rainfall deficiencies nor the "10-year game cycle." It would be desirable to make density correlations such as Herrington (1944) did for the haddock, but I have so far been unable to see how this could be done from the salmon figures presented. Further adding to interpretive difficulties are the two lines of dominant generations that Huntsman (1938) designated. The maintenance of their dominance "seems definitely effected by the dominant year-class keeping down the numbers of the following year-classes, particularly during river life."

Other salmonids have been intensively studied by American investigators. Greeley (1932), discussing significance of egg predators to reproduction in three species of trout in Michigan, first differentiated between eating of waste and viable eggs. He then suggested that: "Even in the event that a large percentage of the total number of viable eggs were to be destroyed, it is possible that enough might remain to produce a number of young sufficient for the carrying capacity of the waters concerned."

Salyer and Lagler's (1940) Michigan study of the American merganser (*Mergus merganser americanus*) in relation to fish management described highly depletive predation upon local populations of trout when exceptionally cold weather concentrated the birds in certain open waters. Little evidence of "buffer" action through the presence of abundant forage fishes was observed. The mergansers not only seemed to have predilections for the larger fishes, but an excessive vulnerability was also "attributed in large part to the lack of good wintering holes for the fish, and to concentrations of trout under the ice which frequently forms over the heavy marginal beds of weeds . . ." Of one river, the authors wrote that during "average weather, few American Mergansers occur on the middle reaches. The number of birds per mile, however, may increase to one hundred or more during the unusual conditions earlier discussed. It is quite possible that such concentrations may deplete the moderate trout population to a level from which recovery to average capacity may require several seasons."

Predation upon fishes, generally, may be said to resemble that suffered by the salmonids. Trowbridge and Whitaker's (1934) description of heron predation upon fishes of drought-shrunken pools in Oklahoma reflects vulnerability and response, depredations that may have had significance to the fish populations or may have been wholly nullified in the end by factors unrelated to predation. Serventy (1938) observed the great populations of small estuarine fishes of southwestern Australia drawing conspicuous predation, but ease of capture by the cormorants studied was only partly a matter of prey abundance.

Some very interesting studies of density effects and predation in Illinois are more or less known to

American ichthyologists but are still largely unpublished. Thompson and Hunt (1930) attributed decreased numbers of fishes and increased sizes of individuals in larger streams to increased predation. Their "26 collections in which the grass pike [*Esox vermiculatus*, a voracious predator] occurred average 2.49 fishes per square yard; and the remaining 86 collections, in which the grass pike did not occur, averaged 5.71 fishes per square yard .... The number of grass pike producing this effect was quite small, averaging only 0.006 per square yard." The effects of predation in regulating populations of centrarchids were especially noted (Thompson, 1941; Bennett, 1944; 1945).

Quoting Thompson as to Lake Senachwine in the Illinois River Valley:

"It was found that game and 'fine' fish (bass, crappies, bluegills, and other sunfish) totalled between 50 and 55 pounds per acre each year... This constancy showed that for the most part the adjustment of the carrying capacity could take place within a single growing season—much faster than is ordinarily supposed. Although the poundage was constant from year to year, a four- and five-year cycle of size and abundance was found. In certain years of this cycle there were ten times as many fish as in other years, but the average weight was only one-tenth as great. The principal cause of this cycle seems to be cannibalism. A few large crappies produce a large brood of young which survive. In subsequent years this dominant brood devours its own young as well as the young of other fish... In this way the crappie not only produces a cycle in its own kind but imposes it on many other non-cannibalistic fish ....

"Besides the compensating cycle of size and abundance within a species, there is a shift among species which does not change the total carrying capacity for 'fine' fish. In some years the black crappie [*Pomoxis nigro-maculatus*] constituted more than 90 per cent of the total... in others it was largely replaced by the white crappie [*P. annularis*] and the bluegill [*Lepomis macrochirus*]." Of the population of another Illinois lake, this one overfished, Thompson (see also Bennett, 1945) wrote that the "scales of these fish show that growth has been greatly accelerated .... Also the natural propagation of young was unusually successful."

Whether we accept Thompson's view that the high reproductive rates of fishes constitute adaptations for living with predators, or feel that the high rates merely encourage predation, it appears true that, when predators are removed, at least the fishes in the habitats he studied "tend to multiply beyond their food resources; they become emaciated and fail to attain sizes attractive to anglers. Fish hatcheries and rearing ponds attract large numbers of fish-eating birds and create one of the more serious predator problems. In the light of our present information it is not impertinent to inquire which helps fishing more, fish-eating birds or fish hatcheries."

In Michigan and Alabama, the experimental manipulations of the same types of fishes have been in progress for many years (Beckman, 1941; Swingle and Smith, 1940; 1943). Stocking procedures for given fish ponds have been pretty well reduced to formula to provide desirable balances between species, including those mutually predatory (Smith and Swingle, 1943; Bennett, 1944).

Bailey and Harrison (1945) found the "ecological picture in Clear Lake [northern Iowa]... [to be] characterized by rapid growth of the fishes... large numbers of predatory fish, and commonly, except during the summer, a scarcity of small fish .... Although Clear Lake is rich in species of minnows, darters, and other forms commonly referred to as forage fish, none is abundant. Those which persist in greatest numbers do so by reason of their choice of protective habitat—dense weed beds, very shallow water, crevices under stones—or because they attain a rather large size. Despite these safety factors, relatively few forage fish attain maturity .... Because of the scarcity of forage fish, young... game and pan fish constitute the staple food supply of the predatory forms .... In spite of the loss of the bulk of the young fish, those remaining are apparently adequate to maintain a satisfactorily large number of adult game and pan fish each year. Years in which few or no young survive are compensated by seasons of greater success, producing 'dominant' year-classes .... Rapid reduction in numbers of young game and pan fish appears to be highly desirable in the maintenance of good fishing conditions .... That this situation is not unique is indicated by studies conducted on Spirit Lake... [where] the same conditions prevail."

Ricker (1945a, b) determined that, in Indiana lakes, a high rate of natural mortality took place among the sizes of bluegills and other pan fishes

available to fishermen. Predation was ruled out as an important cause of death. In one paper (1945a), he critically examined Bidder's (1925) assertion that "it is natural for every fish to have life ended by the fangs or jaws of his fellow-creatures"; and advanced the opposing view that, despite the importance of predation on small fishes, deaths from senility often become predominant among the larger.

Worthington's (1937) comparisons of the fish faunas of a group of African lakes are of notable interest from the standpoint of possible eliminative effects of predation:

"The first striking fact shown by the above [tabulated] figures is that in Lake Albert and Lake Rudolf the family Cichlidae contributed about one-sixth of the whole fish-fauna, while in the other lakes the proportion is always more than a half and sometimes more than three-quarters. The fauna of Lakes Albert and Rudolf are dominated by the great predators *Lates* and *Hydrocyon*, and we are driven to the conclusion that members of these genera have been important factors in controlling the number and variety of Cichlids. The only other lake in the series which contains species of *Lates* and *Hydrocyon* is Tanganyika; but in this case the time factor . . . has been more important in that the lake has been isolated for a much longer period than others in the series, with the possible exception of Nyasa. With a very long time in which to have evolved, the Cichlid fauna of Lake Tanganyika shows a great variety in spite of the control by predators. . ."

But Worthington also wrote that Lake Rudolf had been shrinking "until its level lies more than 100 metres below the old outlet. During this process the dissolved salts . . . have concentrated until the water is now almost undrinkable. The fauna meanwhile has changed in certain respects . . . . Perhaps it may not be too presumptive to assume that the steady change in alkalinity . . . has had its effect on the origin of subspecies in Lake Rudolf."

With respect to at least Lake Rudolf, how then may we be sure that the faunal differences were due to predator pressure any more than—if as much—to non-predacious causes? The stated effect of *Lates* and *Hydrocyon* on the evolution of the cichlids looks to me anything but demonstrated, though, if the author's interpretation is correct, a conditioning role of environment in the predator-prey relationships is still suggested. Might these really be examples of situations in which prey species could have somehow maintained themselves in marginal habitats had they been spared the attentions of formidable predators?

DISCUSSION

At its simplest, predation is akin to grazing, with the prey having no more ability to escape exploitation, when detected by enemies, than have edible pasture growths in the presence of livestock. Movement of the prey adds to the complexity of the predator-prey equations, but frequency of encounter remains a major determinant of the amount of predation suffered by a great variety of invertebrates and lower vertebrates; and this, in turn, is much a function of numbers. Herein also have lain some favorite hunting grounds of mathematicians (Volterra, 1931; Nicholson, 1933; Gause, 1934; Volterra et d'Ancona, 1935; Nicholson and Bailey, 1935; Bodenheimer, 1938; Thompson, 1939).

Ignoring the special complexities inherent in the related parasitism, we may see that predation, even at elementary levels, is not uninfluenced by environmental factors. Gause, Smaragdova, and Witt (1936) demonstrated with microorganisms relationships that were strongly conditioned by escape cover if not by actual threshold phenomena. With regard to insects, we may also find statements similar to those applied to vertebrates—"in nature, when one controlling factor disappears or is diminished in intensity, the effect is automatically reproduced, to a large extent, by other factors . . ." (Thompson, 1939: 325).

Experimental manipulations of invertebrate populations in many laboratories have yielded abundant evidence of density effects. Pearl (1925), Chapman (1931), and Allee (1931) suggested extensions of the principles becoming apparent. Later, Park (1941) examined parallelisms shown by laboratory populations of insects and the concepts of field ecology advanced by Clements and Shelford (1939). Gause (1937), who worked mainly with protozoa, emphasized, as did Park, laboratory experimentation in the study of elements of complexity "in their *relatively simple* form."

Errington, Hamerstrom, and Hamerstrom (1940: 809), considering the experimental results of Gause and co-workers, conceived "of an underlying framework of basic reactions, which, however, may seldom progress to their 'ideal' termination under field conditions because of the . . . interruptions, deflections and compensations so often

attending biotic interrelationships. In nature, reactions of given predator and prey species may indeed barely get started in predictable patterns before deviations occur . . . ." Particularly in higher vertebrates of the north-central United States, "few of the innumerable changes associated with the interrelationships and ecology of the species . . . [studied] appear to be of decisive consequence; in other words, the . . . limitations of animal populations and their resiliences may serve to nullify alike many of the seeming advantages and disadvantages to which fortune may subject them."

The bobwhite-pheasant competition already described illustrates capacities for adjustment that are not apt to show up well in the laboratory. Although pheasants may "have all of the advantage of numbers, adaptations, and habitats . . . it does not necessarily follow that the Bob-white will as a species be evicted from a given locality. It is still possible to find Bob-whites nearly every year in some of the strongest Pheasant range of glaciated north-central United States; data . . . refer to aggregates of two or three coveys of Bob-whites living along the edges of dry marshes frequented by hundreds if not thousands of Pheasants.

"In the above instances, there were two apparent major reasons why competitive interactions between a thriving and another greatly handicapped species did not lead to complete replacement of one by the other, after the manner shown by experiments of Gause *et al* with simple microcosms (Gause, 1935; Gause and Witt, 1935). The Pheasants seldom occupied with any uniformity the whole of the environment suited to Bob-whites but tended to mass along certain sides of a marsh . . . thus leaving at nearly any time a few more or less vacant places to which the Bob-whites could withdraw in comparative privacy. Then, again, the latter birds were not strictly confined to brushy habitats but were able to live more in weed patches, marshy growths, and corn fields . . ." (Errington, 1941b).

Concerning Territoriality and Predation

Inflexibilities are to be seen in natural relationships of north-central mammals and birds, but the population levels maintained by most species that have been carefully studied seldom appear to be linked very closely with gross differences in food and cover, once minimal requirements have been met. While, under extreme conditions, mammals and birds may starve or be lethally exposed, it can be perceived that, when "enough is enough," greater amounts confer little or no advantage. The region's biota is replete with superfluities that tend to be frittered away somehow. Whether one predator or another, or no predator at all, utilizes the surplus of a prey species, or whether a prey species utilizes a larger or a smaller proportion of the food surplus commonly available, it seems that both predators and prey populations of higher vertebrates must be largely self-limited—within, of course, the bounds determined by character of habitats, climatic and other emergencies, cyclic influences, epizootic diseases, etc.

What constitutes a limiting factor may be in itself debatable. Without attempting to go into the philosophical ramifications thereof, we may legitimately question how much some of the factors usually thought of as limiting actually do limit and how much their manifestations—even when pronounced—may be only of incidental or of symptomatic consequence. Appraisals are not simplified by the subtlety with which some truly limiting factors may work, including those which, to quote Pearl and Parker (1922), "in our ignorance we may perhaps tentatively call psychological."

Greater departures in predation patterns from the simpler ones shown by invertebrates and lower vertebrates may naturally be expected in higher vertebrates better able to take care of themselves individually and manifesting more territoriality in one way or another. In this connection, it might be pertinent to quote Naumov's (1939) conclusion that "in a progressive evolution of a certain group there occurs a change in the forms of the struggle for existence. The writer believes that in the case of mammals the primitive form consists in a struggle with a shortage of food which afterwards becomes a struggle against predators and epizooties, being transformed with an increase of immunity and of the vigor of individuals into an intraspecific competition."

In stating a broad rule that the lower vertebrates are greatly more subject to limitation through food or predation than are the strongly territorial (or, at any rate, intraspecifically intolerant) mammals and birds, we must not lay undue emphasis upon phyletic classification. Much variation in behavior is to be witnessed within related groups. Moreau and Moreau

(1938) wrote "that in one species [of East African bishop bird, *Euplectes hordeacea*] the specific territory size can, on present evidence, be regarded as a limiting factor in population density, while in another closely allied and with generally similar habits [*E. nigroventris*], this possibility is excluded," the territories of the latter being "almost indefinitely compressible."

In the Crotophaginae of the American tropics, "the development of social nesting occurs at three levels" (Davis, 1942), reaching its climax in the smooth-billed ani (*Crotophaga ani*) in which "Polygamy or promiscuity is the general rule and the whole colony defends the territory."

The intolerance to crowding that territoriality implies seems to underlie the definiteness of threshold values often recorded for given species on given areas.

The threshold of Gause, Smaragdova, and Witt's (1936) yeast cells (*Saccharomyces exiguus*) fed upon by *Paramecium bursaria* had in no way a fixed value but depended upon the concentration of the yeast. Among higher vertebrates, many contrasts may be ascribed to variations in territoriality.

Population levels of numerous ungulates for which starvation and predation may be judged to be the dominant checks look unstable compared with those of the more self-limited roe deer (Darling, 1937: 92). It may be recalled from the first part of this review that, while Hochbaum (1944) found territoriality strong enough in Manitoba ducks to delimit breeding numbers, weakness of or lack of territoriality in their actual nesting permitted highly vulnerable nest concentrations.

Abnormal concentrations of a great diversity of more or less territorial mammals and birds have been reported (Heape, 1931); and examples of species capable of massing or emigrating on an astounding scale include the notably self-limited and sedentary bobwhite (Schorger, 1944). Self-limitation that permits ascendancies to the thousands of bobwhites that have been seen funnelling through key passageways or blocked by natural barriers may not be very apparent at first glance; but when countless birds happen to be evicted from, or unsettled on, specific tracts of land—yet are indubitably alive and forced to do something with themselves—the drawing together of companies of transients is quite in keeping with their known psychology. While, under these conditions, the birds may be docile toward each other, as members of conspicuous, wandering aggregates, theirs is the status of surpluses. Parallel behavior is repeatedly described in the literature on mouse-like rodents and squirrels.

Davis (1941) remarked upon "the futility of trying to define territorialism strictly." In the tropics, where he worked, "there is a plethora of species, each consisting of relatively few individuals. Unless a species is fairly common, territorial fighting will not have an opportunity to occur and our objective criterion for the recognition of territorialism fails." Certainly, it would not be easy to make a case for the operation of territoriality as a factor limiting species of birds that are consistently too uncommon to show it (see also Lack, 1937; Nice, 1941)—though intolerance need not take the form of fighting or displays, nor scarcity alone prevent manifestations of intolerance.

Tinbergen's (1936) linking of sexual fighting with the origin of territory in birds properly stays within the scope of his paper but invites an expansion of territorial concepts. If we disregard the more restricted usages of territoriality and the mating of animals, we can lead up to the biological base levels suggested by the data on muskrats and bobwhites, the breeding season densities of which seem profoundly influential in population mechanics over most of the calendar year, and especially in the sense that the resulting intolerances affect rates of gain and loss and general vulnerability to predation.

Nicholson (1933: 171) likened the system of balance in territorial animals to "water in an overflowing reservoir." In cases where territoriality results in an expulsion of surpluses into virtually uninhabitable environments, it is not difficult to understand the mechanics of intercompensations in loss rates. Emergencies evicting or imposing lethal handicaps on populations work similarly, except that the processes are accelerated. Population surpluses of muskrats and bobwhites "normally" tend to disappear in the course of months, whereas under the impacts of emergencies the parts of populations affected may be overwhelmed far more rapidly.

Concerning Variables Appraisable With Difficulty

The confusion created by emergencies and depression phases operating simultaneously—as they often do—is not alleviated by certain resemblances in their population effects. After dis-

sociating the effects of these two variables as well as hiatuses in our data and understanding permit, we may make out a region-wide synchrony in the periods of great depressive influence, coming at approximately 10-year intervals and affecting nearly all North American vertebrates for which figures eligible for comparison have been published.

There are scant grounds for challenging the reality of the subnormal food supplies, the heavy infestations by parasites, the mortality from predators or disease, the losses of the immature during adverse weather, the miscellaneous factors to which competent investigators have ascribed declines of wild vertebrates in 1936 and 1937, the best-studied low of the "10-year game cycle" in the north-central and northeastern United States—and possibly in other regions or even other continents, as 1936 and 1937 were also years important in the declines of British mice, hares, and gallinaceous game (Elton, 1935–37). Nevertheless, these things are frequently to be observed in ordinary years, when their population effects are clearly offset by automatic adjustments. Indeed, some of the failures to adjust may be as indicative of cyclic influences as anything in the over-all picture.

Restricting our attention to North America, we may not only see that the low of the cycle centering about 1936–37 came earlier or later in some regions than in others, but also that further analytical difficulties result from superimposed shorter-term cycles. Numbers of mice or of lemmings (especially *Dicrostonyx* spp.), with their own three- or four-year cycles (Braestrup, 1941; Elton, 1942; Shelford, 1943), and numbers of associated foxes, raptorial birds, hares, ptarmigans, etc., may or may not be in agreement. The complexities revealed by Braestrup's account of Greenland's foxes and fox foods and a reviewer's logical doubts as to "the propriety of using figures compiled from . . . diverse and varying sources to demonstrate cyclic phenomena" (Cross, 1940) may alone discourage hope for anything approaching a solution for years to come. And there are the usual shortages of data as to population gains or losses in relation to density, which data, I am convinced, are incomparably more valid as criteria of real depression phases than are statistics on gross fluctuations.

The information published on the Galliformes during lesser depression phases suggests changing intensities of whatever may be the dominating influence. The manifestations of the changes differ from those of an emergency chiefly in that, despite irregularities in chronology, patterns of response to density are sufficiently defined to give the gear-shift effect intermediate between "normal" threshold behavior and the extreme depressions at the lows of the "10-year game cycle." Causes of such changes in density responses are perhaps even less easily explainable theoretically than are the synchronized cyclic lows, but their observed definiteness for populations during given phases would seem disproof of their having any primary basis in variations in predator pressure.

It is fair to ask how much predators may accentuate vulnerability or make marginal environment uninhabitable, particularly when the predators are of types capable of exerting great local pressure upon the prey. We may see, or at least conceive of, non-compensatory aspects of some of the predation suffered. Examples range from the restriction of young salmon by fish-eating birds to but few of the parts of streams that otherwise could be occupied (White, 1937; 1939), to elimination by wolves of Dall sheep trying to live away from the better mountain retreats (A. Murie, 1944), and Arctic foxes indirectly setting upper limits to densities of colony-nesting sea birds through their depredations on the sites for colonies that they find accessible (Bertram and Lack, 1938).

Even in a species showing such pronounced intercompensations as the bobwhite in the northern states, the fate of certain coveys may at times appear conditioned by the nature of the predatory harassment experienced. The net effects of a red-tailed hawk attending a covey of starving birds, of night-flushing by foxes in very cold weather, of a flight of goshawks in the dead of winter, all may be hard to evaluate.

Concerning Intercompensations

We should always be careful not to attach too much analytical significance to severe local predation, as automatic balancing has ways of taking place over larger areas. Roebuck (1938), in two surveys of the British Midlands spaced four years apart, found that the number of nesting rooks (*Corvus frugilegus*) "had remained constant, but for various reasons 14% of the nesting sites had changed"—not to be considered a four-year change but "more nearly an annual change." Like the local population shifts without any change of threshold values, earlier described for

muskrats, bobwhite thresholds may look plainly variable in the smaller "territorial" units without losing their constancy for the same units viewed as a collective group (Errington, 1945: 12).

Lehmann (1946a, b) obtained unusually complete nesting and banding data from a two-year investigation of bobwhites on a 960-acre Texas area. In the spring of 1943, coyotes destroyed 58 per cent, and skunks 12 per cent, of the nests, leaving 30 per cent successfully hatching. For the midsummer period, the loss of only 25 per cent of the nests was traced to coyotes, and the author wrote (1946a): "Damage by skunks and by coyotes was not intercompensatory; i.e., skunk damage did not increase as coyote pressure decreased . . ." Snakes and miscellaneous failures brought the total non-coyote loss rate up to 18 per cent, which might represent a partial compensation. For the late summer of 1942 (the only season of that year for which data were presented), the coyote was listed as the sole agency of the 51 per cent nest destruction. "The somewhat lower loss [33 per cent of nests destroyed by coyotes] late in the summer of 1943 may have resulted from intensive coyote trapping from May to July in the pasture where many study nests were located." Yet, all late-summer losses of nests in 1943 came to 51 per cent, as in 1942.

The 30 per cent of the nests that were successful in the spring of 1943 produced an average of 14 chicks or about twice as many each as the late summer nests, of which nearly half succeeded. The 57 per cent success of the midsummer nests was believed largely due to seasonal changes in habits of the coyotes, but its possible relation to a more favorable part of the bobwhite's nesting span or to the heavier earlier losses it tends to offset should be considered. Far from proved is the thesis that "the annual production would have been about doubled if early nests had been successful."

Autumn and winter populations were designated as "poor barometers of breeding success on static ranges unless the latter are decidedly underpopulated. The rate of increase tends to be inverse to breeding density on static range, but breeding success is not necessarily inverse to population density. In such areas, summer spread may siphon off much of the annual increase before autumn." Increases of *net* productivity resulting from the saving of early nests would be contingent upon the existence of unfilled habitat for locally hatched and reared birds to spread into. In Lehmann's words: "Ample range to accommodate increase was available, for the Jones Wildlife Refuge [including the study area] as a whole (165,000 acres) and the surrounding territory were underpopulated." The degree of underpopulation must not have been pronounced, for, in his companion paper (1946b), he described the study area as being "completely surrounded by miles of 'wild' ranch lands supporting heavy quail populations . . ."

Reporting on the banding, 1942–43, of 1659 bobwhites on his main 960-acre area and of 850 others on adjacent ground: "Some individuals and coveys were relatively sedentary, but the population as a whole underwent continuous movement." He referred to consistently good habitats and obviously did not regard the birds as constituting insecure surpluses; for all of that, his stated densities were so high (at averages between 1.30 and 2.54 and usually near 1.50 acres per bobwhite) that they surely could have been expected to promote restlessness. Accelerated shifting in the north-central bobwhites was clearly in response to overcrowding, in addition to other pressures; and winter densities averaging higher than four acres per bird (which would seldom be reached in any but the superior "quail country" of the region) were accompanied by so much mixing that accurate census figures through field counts became almost unobtainable despite the tremendous advantage conferred by tracking snows (Errington and Hamerstrom, 1936: 318–319).

In the winter of 1942–43, prior to the time of Lehmann's (1936b) peak densities, ingress recorded on the 960 acres "totalled at least 230 birds" and the "turnover on the study area during the winter . . . was at least 72 per cent." These data, in combination with the information on movements of individuals, suggest fair, if not equalizing, numbers of birds outside of the area's boundaries. Hence, when adults outnumbered young during the population maximum of 1943 (compared with a 2.5:1 ratio of young to adults in 1942), the author's conclusion (1946a) "that a large segment of the 1943 increase moved from the study area before autumn set in" still does not answer questions as to how representative the 1943 densities and age ratios may have been for extensive tracts of land, on and off the area.

Of course, in view of Lehmann's banding data and the small size of his area, his spring-to-fall population gains do not reflect, exclusively or principally, the net reproductive success of the *identical* spring residents—no such assumptions being justified for much larger areas of contiguous bobwhite range (Errington, 1945: 12–13, 20–21). But were the low net gain for 1943 and the high proportion of adults attributable wholly to a greater proportion of the season's young leaving the vicinity of the area and were these young to become safely established in quarters elsewhere, the data would show nothing contrary to the general evidence on intercompensatory trends. The rates of net increase (58 per cent from 378 in 1942 and 18 per cent from 619 in 1943) re-emphasize the basic tendencies toward levelling off, in which postbreeding adjustment may be as prominent a mechanism as outright mortality.

Particularly in the literature on applied biology may we be impressed by the tendency of the human mind to overestimate the effects of predation upon the wild-living species that man either regards as pests or wants to encourage. In game management programs where attempts have been made to reduce losses or to increase rates of gain of mammals or birds through the repression of predators, truly demonstrable success has commonly been modest when compared with the sporting public's expectations or claims. More often than not, the apparent successes consisted of postponing the times of the main automatic adjustments, perhaps to practical advantage, perhaps not.

Regardless of the great difficulties in appraising European game-keeping practices from the standpoint of population effects, it would seem probable that the emphasis placed upon all possible elimination of natural losses does result in a bolstering of biologically top-heavy densities of game species beyond levels otherwise to be maintained. Whether such highly artificialized management increases helplessness of native species or not, evidences of intercompensatory trends continue to be revealed by the information published, as the protected species suffer what look like extraordinarily heavy losses though the agencies of the predators happening to escape the campaigning of the keepers. Judging from the latters' complaints, practically anything capable of eating flesh (including predators of very minor types compared with the formidable predatory faunas of North America) can inflict destruction upon their charges. The stated consequences of lax keepering are often unconvincing because of mixed variables. A decline of game in the British Isles during the later years of the first World War was laid to an increase of "vermin" while so many of the keepers were in military service, yet this decline at least coincided with a low of the "10-year game cycle" in North America. On the premises of American game breeders, predators attracted by concentrations of prospective prey may be diligently trapped and shot, notwithstanding which, "The yearly toll taken by predators on many game farms is almost constant, indicating that no real progress has been made even when wholesale control is attempted" (Grange and McAtee, 1934).

Indeed, with respect to predation on vertebrate populations, the following generalizations are warranted. Intercompensations vary in their known importance in the life-equations of different animals; they may follow easily predictable patterns or they may not; they may operate amid the immensities of wastage and the cheapness of life in crowded colonies, or they may reflect ease of living in underpopulated habitats. They may be conditioned by density as such, or by density in relation to capacity for accommodation of environmental niches, in relation to psychological toleration points, or in relation to depression phases, and probably in relation to more other factors than anyone will ever enumerate, let alone understand; but few are the predator-prey situations for which it can reasonably be claimed that automatic counterbalancing does not occur.

Conceded, that a great deal of the predation falling in the category of special cases is less likely to be offset by intercompensations in the loss and recovery rates of the prey. Surely, we may not look for much significant intercompensation when insular species are wiped out by predatory invaders, and the plight of the Australian marsupials beset by exotic predators and competitors (Harper, 1945: 9–10, 22–121) implies big failures in adjustment mechanisms. Nor should one forget the hunting prowess and selectivity exhibited on occasion by the canids and man. Modern man, with the advantage given him by his equipment, has unique potentialities for depleting or directly exterminating certain wild species, but others are rather well able to take human hunting "in stride." Shooting and trap-

ping, in moderation and directed mainly against surpluses, has about the same population role as ordinary predation by native enemies, acting as a substitute for part of the predation more than as a superimposed pressure. The facility with which common game learns of weapons also helps to keep the biological impacts of human predation more comparable to the subhuman.

Except as influenced by superstitions, refinements of methods, etc., I cannot see that predation by primitive men differed so essentially from that of their fellow-predators, the wolves. In a stone-age economy, American Indian hunting practices—the resultant of convenience as well as of special motivations—tended to be wasteful when game was easy to get, conservative when they had to be (Presnall, 1943). Kitchen middens show that food habits were determined both by the people's predilections and by the availability of the prey; two about which I happened to have read contained bones of just about the fauna that Indians living on the shore of a California lake 500 years ago would have found exploitable (DeMay, 1942).

That the American Indians, before their corruption by Caucasians, subsisted mainly on surpluses seems to be generally believed. In a case cited and commented upon by Clarke (1942), the dying of northern Indians from smallpox epidemics in the eighteenth century was not followed by noticeable increase of animals thus relieved of hunting pressure.

In endeavoring further to explore the phenomena of intercompensatory trends, we may think of these as being to some degree merely a function of numbers. This is not another way of saying that differences in rates of gain or loss are cancelled out in the end in so far as all living things ultimately must die, for a great deal of the compensating occurs within a sufficiently short time to have real significance in the population status of a species. The tendencies for rates of gain, spring to fall, of higher vertebrates to be in inverse ratio to adult densities and for rates of non-emergency loss to conform to patterns at different seasons of the year have their predetermined aspects; and the linkages of these rates with the unexplained though influential depression phases constitute more proof of the operation of a fundamental mechanism. I have been unable to follow this through to my full satisfaction, but there is something here to remind one of Pearl's (1932) analogy between the behavior of his fruit flies and of the molecules in a gas, something that would seem based upon random contacts with dangers increasing with density.

We might expect that conditions would thereby exist for the sort of predation McAtee (1933) concluded to be "proportional to population, the proportion, however, rising and falling progressively with increase or decrease in the numbers of the available food organisms." Such would appear reasonably close to the known truth if the picture were considered not merely from the standpoint of predation but also in terms of collective losses, and if allowances were made for the more sweeping types of emergencies, phase effects, threshold phenomena, etc.

Concerning Natural Selection

I confess to being anything but sure of myself in the welter of statistics, computations, speculations, and personalities comprising recent literature on natural selection, but it is plain that much factually shaky theory has originated through misappraisals of predation as a population depressant. Furthermore, some of the works differing in methods and opposing in conclusions may each contribute valuable information on restricted aspects of the problem. In contrast, Cushing's (1939) field observations were of predatory birds detecting prey by movements rather than by coloration, and Popham's (1942) experiments with fishes showed differential feeding upon the insects that were less in harmony with their color backgrounds. Neither study told what happened to a prey species beset by enemies employing variable methods of search and attack under variable circumstances, as is so often the case in nature. An attribute of a prospective prey animal either may or may not have demonstrable survival value against a specific predator, but the cross-fire effect of natural mortality on a part of a population that is vulnerable, let us say, because of density certainly is capable of a great deal of counteracting.

Here, as I see it, is the outstanding strength in McAtee's philosophical position. For all of the bitterness occasioned by his stand (1932) against the efficacy of natural selection, he has been one of the few whose publications have revealed noteworthy awareness of intercompensations. Judging from those higher vertebrates (especially muskrats and bobwhites) with which I am the most familiar, I feel that, while he (1937) has overrated the eliminative effects of sweeping

mortalities, at the same time underrating the possible effectiveness of small degrees of selection (Errington, 1943: 902), his major contentions have truths in them that are too fundamental for objective critics to disregard. In biotic systems dominated by internal population controls, mortality that is mainly a by-product of population (as is the great preponderance of the predation loss suffered by common vertebrates) can have but very limited selectivity.

The muskrats and bobwhites would appear decidedly more susceptible to selective influences operating through emergency crises and competition than through the severest observed types of subhuman predation, although, let it not be forgotten, the predation can at times eliminate great numbers of individuals and may even "normally" be the agency of most deaths. Notably on the high plains frontiers of muskrat and bobwhite ranges, the lines of genetic continuity may be pretty well thinned out by ordeals of drought or cataclysmic winters, yet, by escaping complete termination, may conform to Wright's (1940) "important case . . . where local populations are liable to frequent extinction, with restoration from the progeny of a few stray immigrants."

My own opportunities for studying drought in relation to Iowa and South Dakota muskrats have left me with a belief that such a factor can select for fecundity if nothing else (Errington, 1943: 899–903). Without implying that there is anything unfit about the less fecund of the "normal" animals, I would say that large-littered strains of *Ondatra z. zibethicus* in Iowa would fill proportionally more of the immense expanses of underpopulated muskrat habitats that sooner or later await recolonization following the famous droughts of the northern prairies. The Iowa litters did average 6.5 young shortly after birth, compared with averages of about four young for *O. z. macrodon* in Maryland and *O. z. rivalicia* in Louisiana. (Naumov (1945) wrote that the fertility of other mouse-like rodents increased away from ecologically optimum zones, as weather conditions "begin to prevail in the mechanism of the fluctuation in numbers.") To this extent, the muskrat data would seem to bear out Severtzoff's (1934) emphasis of the importance of rapid recovery of a species after an "abiotic plague," but hardly his thought that "In order to secure the survival of a number of individuals sufficient for the continuation of the race, the species have to attain their highest possible numbers in the course of the period favorable for reproduction."

Arguments as to the role of differential fertility in enabling those mammals and birds I have studied closely to maintain their kinds against enemies leave me quite unconvinced. The Iowa data on the undeniably fecund muskrat, "as interpreted, do not support the thesis that . . . the more prolific a race . . . may be, the better it is adjusted to withstand predator pressure. It seems highly probable that the more prolific a race is, the more predation it will draw, which is a different thing from keeping ahead of its enemies through sheer rapidity of increase. Here, again, the old 'fallacies of misplaced concreteness' add their confusion, to perceive which we need but remind ourselves of the nature of predation upon the muskrats.

"Patently, the self-limiting mechanisms behind muskrat population phenomena operate only partially through reduction in numbers of individuals born per breeding female and then largely during periods of emergency or in years marked by either extremely low or extremely high muskrat densities . . .. The theoretical advantages of many or larger litters are in good measure nullified by greater wastage . . . . Conversely, the theoretical disadvantages of few or smaller litters become counterbalanced by superior chances for survival of the young that are born, with resultant diminishing in manifestations of predation" (Errington, 1943: 899).

Attempts to judge exactly when a species is or is not out of its habitat are all but overwhelmed before they get far, by the complexities of life, itself. Elton's (1939) short essay on cover is enough to cause doubts as to what is known of the "simpler" aspects of protection. Referring to bird habitats of British heathlands, Lack (1937) italicized his statement that the significant features often vary markedly within the space of ground occupied by one breeding pair. Specific habitat requirements for passerine birds may be extremely variable (Kendeigh, 1945). When we take up such things as coloration of mammals in relation to soil colors (Dice and Blossom, 1937; Hardy, 1945) and Sumner's (1932: 73–86) "gradients of population pressure" between subspecies of deer mice, we may further wonder just where the lines lie between predation as an evolutionary force and as a totally incidental accompaniment of populations.

Following a trapping and marking study of the two mice, *Apodemus sylvaticus* and *Clethrionomys glareolus*, 1936–39, on a local area in England, Evans (1942) advanced an "interpretation of the relationship of population fluctuations . . . [that] differs from other theories. For example Naumov . . . has suggested that when a population is at its lowest density it occupies only the most favourable habitats; that as the density increases, the pressure of numbers forces the population into less favourable habitats until a maximum density is reached when all possible habitats are occupied; and that periodic decreases of the population caused by migration or disease result in the occupation of only the most favourable habitats. The use of the term *favourable* seems somewhat misleading here. The new interpretation suggests that habitats which will permit high densities of animal populations will also permit high densities of predators and parasites whose decimating effect may be so rapid as virtually to destroy those populations; habitats which will maintain only low densities may in the long run be essential to the survival of the species."

Naumov (1937b) had endorsed "Kalabukhov's point of view [see also quotations from Elton earlier in this paper] that the activity of predators, determined both by the environmental conditions and the spreading of rodents, represents the main factor in the control of small rodent numbers"; and, in connection with this, there remain the questions previously brought up as to what actually exerts the control, predators or, basically, something else. The quotation from Evans imputes more depressive power to predation upon mouse occupants of heavily populated habitats than it is at all likely to have, but, during lethal epizootics, those places characteristically accomodating low densities may indeed afford the safest refuges for a species.

Recent Iowa field researches (Errington, 1944, and unpublished) on the epidemiology of what can be a most eliminative disease of muskrats indicate that drought and disease, one centering on marginally situated populations and the other on the denser aggregates, would be extremely effective agencies of reduction when working in combination. At any rate, we repeatedly have periods when, in consequence of great losses of muskrats, low populations find themselves in lush habitats; and when most of the young born will probably be raised—as is often the case at such times of minimal population pressure—the fast-expanding genetic groups will have some initial exploitative advantages. Irrespective of the automatic balancing that becomes operative when population surpluses are once again being frittered away, natural selection may be said to have occurred if a change in the fecundity of a population was indeed promoted by the droughts and epizootics. Human over-trapping for fur (Errington, 1940) or systematic persecution (Ulbrich, 1930; Storer, 1937; Warwick, 1940) could likewise be drastic enough similarly to select for fecundity, but this cannot logically be claimed for predation upon the muskrat by wild flesheaters.

I have admittedly gone almost as far as I can in discussing natural selection without getting off familiar grounds. It is not my intention to contend that sub-human predation is always without selective influence. The canids, which are not wholly beyond comparison with man in potential destructiveness, may exert pressures that really count, as may, at times, some other forms. The literature on island-nesting birds furnishes good examples of eliminative or restrictive predation; and such mainland vertebrates as predation excludes from specific habitats conceivably might experience modification thereby. Nevertheless, I cannot see that most types of the incidentally operating predation drawn by vertebrates could do much selecting. "Perhaps," as Hubbs (1944) wrote in review of my (1943) analysis of mink predation upon muskrats, "one of the leading adaptations has been the perfection of the 'intercompensatory trends'."

From the available and understandable evidence, it appears that natural selection, while grossly overplayed in predation theory, still does exist as a phenomenon. As nearly as I can judge, my concepts of the subject may be classed as somewhat intermediate between those of McAtee and of Wright (1932; 1945), the latter of whom has carefully gone into the statistics of Mendelian inheritance. Like Sumner's (1932: 73) "compromise verdict," occasioned by the complexities brought out by his genetic studies of mice, mine, I suppose, must be one "of a decidedly banal character, but it none the less seems to accord best with our present knowledge."

SUMMARY

An attempt has been made to appraise the population effects of predation upon vertebrates, particularly through the consideration of auto-

matic adjustments or intercompensatory trends in rates of gain or loss in prey populations.

After distinguishing between the more or less inexorable factors underlying the vulnerability of a population to predation and the responsiveness of predators that may be symptomatic of vulnerability, we may see that a great deal of predation is without truly depressive influence. In the sense that victims of one agency simply miss becoming victims of another, many types of loss—including loss from predation—are at least partly intercompensatory in net population effect.

Regardless of the countless individuals or the large percentages of populations that may annually be killed by predators, predation looks ineffective as a limiting factor to the extent that intraspecific self-limiting mechanisms basically determine the population levels maintained by the prey. A certain degree of correlation indeed seems to exist between territoriality (or intolerance, in one form or another) and lack of effectiveness of subhuman predation as a population check. In considering the classes of vertebrates, we may find far better examples of relatively complete intercompensations shown by highly territorial (or intolerant) mammals and birds than in the less territorial fishes, and more evidence of significant population effect of predation upon the fishes.

Among the mammals and birds, the numbers of those tolerant of crowding (such as some of the ungulates and waterfowl) appear most influenced by predation, but there are too many special cases presented by insular species and forms unable to cope with exotic predators, etc., to allow easy generalizations. Unanswered questions also remain as to what proportions of the habitats that are marginal for various prey species might accommodate greater populations were it not for interspecific predation. Then, too, so large a proportion of the known depressions of populations of mammals and birds through predation is linked with exploits of the dog family and of man that the consequences described might very possibly have been due to the rather unique pressures that these astute and often selective predators are capable of exerting.

On the whole, in view of the usual human tendencies to overestimate the population effects of conspicuous or demonstrably heavy predation, something of a scaling down of emphasis should well be in order, notably in appraising the role of direct predation in the population mechanics of higher vertebrates. Thresholds of security and their associated inverse relationships between the numbers of adults resident and the numbers of young produced or tolerated are frequently suggested by the published data, and these in turn quite evidently operate in conjunction with characteristics of habitat and with "cyclic" and other depression phases; but the patterns revealed may look remarkably little influenced by variations in kinds and numbers of predators. Even in equations depicting predator-prey interactions in lower vertebrates, loss types may substitute naturally for each other instead of pyramiding, and compensatory reproduction should not be ignored when a resilient instead of a rigid fecundity is indicated.

LIST OF LITERATURE

ALEXANDER, W. B. 1945. The index of heron population, 1944. *Brit. Birds*, 38: 232–235. (Not seen; ref. Elder, 1945.)

ALLEE, W. C. 1931. *Animal Aggregations. A Study in General Sociology.* Univ. Chicago Press, Chicago. 421 pp.

——. 1938. *The Social Life of Animals.* W. W. Norton, New York. 293 pp.

ALLEN, A. A. 1924. A contribution to the life history and economic status of the screech owl (*Otus asio*). *Auk*, 41: 1–16.

ALLEN, D. L. 1942. Populations and habits of the fox squirrel in Allegan County, Michigan. *Amer. Midl. Nat.*, 27: 338–379.

——. 1943. *Michigan Fox Squirrel Management.* Mich. Dept. Conserv., Lansing. 404 pp.

——, and W. W. SHAPTON. 1942. An ecological study of winter dens with special reference to the eastern skunk. *Ecology*, 23: 59–68.

American Ornithologists' Union. 1931. *Check-List of North American Birds.* 4th Ed. Lancaster Press, Lancaster, Pa. 526 pp.

Anonymous. 1944. Record duck flight U. S.-bound despite huge breeding loss. *N. Dak. Outdoors*, 7 (4): 7–9.

ARTHUR, S. C. 1931. The fur animals of Louisiana. *La. Dept. Conser. Bull.*, 18 (Revised). 444 pp.

ASDELL, S. A., R. BOGART, and G. SPERLING. 1941. The influence of age and rate of breeding upon the ability of the female rat to reproduce and raise young. *Cornell Univ. agric. Exp. Sta. Mem.*, 238. 26 pp.

AUSTIN, O. L. 1946. The status of the Cape Cod terns in 1944; a behavior study. *Bird Banding*, 17: 10–27.

BABCOCK, M. J., R. BOGART, G. SPERLING, and S. A. ASDELL. 1940. The reproductive efficiency of the albino rat under different breeding conditions. *J. agric. Res.*, 60: 847–854.

BABCOCK, J. P., W. A. FOUND, M. FREEMAN, and H. O'MALLEY. 1930. Report of the International Fisheries Commission appointed under the Northern Pacific Halibut Treaty. *U. S. Dept. Com. Bur. Fish. Doc.*, 1073. 25 pp.

BACH, R. N. 1944. Population fluctuations of the North Dakota pheasant 1938–1943. *N. Dak. Outdoors*, 6 (7): 8–10.

BAILEY, R. M., and H. M. HARRISON, Jr. 1945. The fishes of Clear Lake, Iowa. *Iowa State Coll. J. Sci.*, 20: 57–77.

BAILEY, V. 1924. Breeding, feeding, and other life habits of meadow mice (*Microtus*). *J. agric. Res.*, 27: 523–535.

BAKER, R. H. 1940. Crow depredations on heron nesting colonies. *Wilson Bull.*, 52: 124–125.

BARBOUR, T. 1926. *Reptiles and Amphibians. Their Habits and Adaptations.* Houghton Mifflin, Boston. 125 pp.

BARNEY, R. L., and B. J. ANSON. 1920. Life history and ecology of the pigmy sunfish, *Elassoma zonatum*. *Ecology*, 1: 241–256.

BAUMGARTNER, F. M. 1939. Territory and population in the great horned owl. *Auk*, 56: 274–282.

——. 1944a. Dispersal and survival of game farm bobwhite quail in northcentral Oklahoma. *J. Wildlife Mangt.*, 8: 112–118.

——. 1944b. Bobwhite quail populations on hunted vs. protected areas. *J. Wildlife Mangt.*, 8: 259–260.

BECKMAN, W. C. 1941. Increased growth rate of the rock bass, *Ambloplites rupestris* (Rafinesque), following reduction in the density of the population. *Trans. Amer. Fish. Soc.*, 70: 143–148.

BEECHER, W. J. 1942. *Nesting Birds and the Vegetation Substrate.* Chicago Ornith. Soc., Chicago. 69 pp.

BENNETT, G. W. 1944. The effect of species combinations on fish production. *Trans. N. Amer. Wildlife Conf.*, 9: 184–188.

——. 1945. Overfishing in a small artificial lake. *Bull. Ill. Nat. Hist. Surv.*, 23: 373–406.

BENNETT, L. J. 1938. *The Blue-winged Teal; its Ecology and Management.* Collegiate Press, Ames, Iowa. 144 pp.

——, and G. O. HENDRICKSON. 1938. Censusing the ringneck pheasant in Iowa. *Trans. N. Amer. Wildlife Conf.*, 3: 719–723.

BENT, A. C. 1919. Life histories of North American diving birds. Order Pygopodes. *Bull. U. S. nat. Mus.*, 107. 245 pp.

——. 1923. Life histories of North American wild fowl. Order Anseres. I. *Bull. U. S. nat. Mus.*, 126. 250 pp.

——. 1925. Life histories of North American wild fowl. Order Anseres. II. *Bull. U. S. nat. Mus.*, 130. 376 pp.

——. 1937. Life histories of North American birds of prey. Order Falconiformes. I. *Bull. U. S. nat. Mus.*, 167. 407 pp.

BERGMAN, G. 1939. Untersuchungen über die Nistvogelfauna in einem Schärengebiet westlich von Helsingfors. *Acta Zool. Fennica*, 23. 134 pp.

BERRY, J. 1939. *The Status and Distribution of Wild Geese and Wild Duck in Scotland.* University Press, Cambridge. 190 pp.

BERTRAM, G. C. L., and DAVID LACK. 1938. Notes on the animal ecology of Bear Island. *J. Anim. Ecol.*, 7: 27–52.

BIDDER, G. P. 1925. Constant differential growth-ratios and their significance. *Nature, Lond.*, 115: 155–156.

BIRD, C. G., and E. G. BIRD. 1941. Conditions in northern breeding areas of wildfowl North-east Greenland. In *Factors Affecting the General Status of Wild Geese and Wild Duck (International Wildfowl Inquiry, Vol. I).* University Press, Cambridge. Pp. 13–14.

BIRD, R. D. 1930. Biotic communities of the aspen parkland of central Canada. *Ecology*, 11: 356–442.

BLACK, J. D. 1932. A winter robin roost in Arkansas. *Wilson Bull.*, 44: 13–19.

——. 1945. Natural history of the northern mimic shiner *Notropis volucellus volucellus* Cope. *Invest. Ind. Lakes and Streams*, 2: 449–469.

BLAIR, W. F. 1938. Ecological relationships of the mammals of the Bird Creek Region, Northeastern Oklahoma. *Amer. Midl. Nat.*, 20: 473–526.

——. 1940a. Home ranges and populations of the meadow vole in southern Michigan. *J. Wildlife Mangt.*, 4: 149–161.

——. 1940b. Notes on home ranges and populations of the short-tailed shrew. *Ecology*, 21: 284–288.

BODENHEIMER, F. S. 1938. *Problems of Animal Ecology.* Oxford Univ. Press, London. 183 pp.

BRADT, G. W. 1938. A study of beaver colonies in Michigan. *J. Mammal.*, 19: 139–162.

BRAESTRUP, F. W. 1941. A study on the Arctic fox in Greenland. Immigrations, fluctuations in numbers based mainly on trading statistics. *Medd. Grønland*, 131 (4). 101 pp.

BRAGG, A. N. 1944–45. The spadefoot toads in Oklahoma with a summary of our knowledge of the group. *Amer. Nat.*, 78: 517–533; 79: 52–72.

BREDER, C. M., JR. 1936. The reproductive habits of the North American sunfishes (Family Centrarchidae). *Zoologica*, 21: 1–48.

BREDER, C. M., JR., and C. W. COATES. 1932. A preliminary study of population stability and sex ratio of *Lebistes*. *Copeia*, 1932: 147–155.

BRINKMAN, M. 1934. Die Veränderungen im Bestande des weissen Storches (*Ciconia ciconia*) in Oberschlesien. *J. Orn., Lpz.*, 82: 420–434.

BROWN, R. H. 1939. Notes on the lapwing and curlew breeding populations of a Cumberland farm. *Brit. Birds*, 33: 12–15.

BULLOUGH, W. S. 1942. Observations on the colonies of the Arctic tern (*Sterna macrura* Naumann) on the Farne Islands. *Proc. zool. Soc. London*, A, 112: 1–12.

BURT, W. H. 1940. Territorial behavior and populations of some small mammals in southern Michigan. *Misc. Publ. Mus. Zool. Univ. Mich.*, 45. 58 pp.

CAGLE, F. R. 1942. Turtle populations in southern Illinois. *Copeia*, 1942: 155–162.

CARPENTER, C. R. 1934. A field study of the behavior and social relations of howling monkeys (*Alouatta palliata*). *Comp. Psychol. Monog.*, 10 (1). 168 pp.

——. 1940. A field study in Siam of the behavior and social relations of the gibbon (*Hylobates lar*). *Comp. Psychol. Monog.*, 16 (5). 212 pp.

CARR-SAUNDERS, A. M. 1922. *The Population Problem. A Study in Human Evolution.* Clarendon Press, Oxford. 516 pp.

CARTWRIGHT, B. W. 1944a. The "crash" decline in sharp-tailed grouse and Hungarian partridge in western Canada and the role of the predator. *Trans. N. Amer. Wildlife Conf.*, 9: 324–330.

——. 1944b. Waterfowl brood counts in Manitoba, Saskatchewan, and Alberta, 1935, 1938–42. *J. Wildlife Mangt.*, 8: 79–80.

CHANCE, E. P., and H. W. HANN. 1942. The European cuckoo and the cowbird. *Bird Banding*, 13: 99–102.

CHAPMAN, F. B. 1938. Summary of the Ohio gray squirrel investigation. *Trans. N. Amer. Wildlife Conf.*, 3: 677–684.

CHAPMAN, L. B. 1939. Studies of a tree swallow colony (second part). *Bird Banding*, 10: 61–72.

CHAPMAN, R. N. 1931. *Animal Ecology with Special Reference to Insects.* McGraw-Hill, New York. 464 pp.

CLARKE, C. H. D. 1936. Fluctuations in numbers of ruffed grouse, *Bonasa umbellus* (Linne), with special reference to Ontario. *Biol. Ser. Univ. Toronto Studies*, 41. 118 pp.

——. 1940. A biological investigation of the Thelon Game Sanctuary. *Bull. nat. Mus. Canada*, 96. 135 pp.

——. 1942. The Indian as a conservationist. *Canad. Field Nat.*, 56: 127–128.

CLEMENTS, F. E., and V. E. SHELFORD. 1939. *Bio-Ecology.* Wiley, New York. 425 pp.

Committee of Inquiry on Grouse Disease (Gt. Brit. Dept. Agric. and Fish). 1911. *The Grouse in Health and Disease, etc.* (2 vols.). Smith, Elder, London.

CONGREVE, W. M., and S. W. P. FREME. 1930. Seven weeks in eastern and northern Iceland. *Ibis*, 1930: 193–228.

CRABB, W. D. 1941. Food habits of the prairie spotted skunk in southeastern Iowa. *J. Mammal.*, 22: 349–364.

——. 1943. Ecology and management of the prairie spotted skunk, *Spilogale interrupta* (Rafinesque), in southeastern Iowa. *Iowa State Coll. J. Sci.*, 18: 22–24.

CRIDDLE, S. 1926. The habits of *Microtus minor* in Manitoba. *J. Mammal.*, 7: 193–200.

——. 1930. The prairie pocket gopher, *Thomomys talpoides rufescens*. *J. Mammal.*, 11: 265–280.

——. 1938. A study of the snowshoe rabbit. *Canad. Field Nat.*, 52: 31–40.

CROWELL, E. M., and S. CROWELL. 1946. The displacement of terns by herring gulls at Weepecket Islands. *Bird Banding*, 17: 1–10.

CROSS, E. C. 1940. Periodic fluctuations in numbers of the red fox in Ontario. *J. Mammal.*, 12: 294–306.

CUSHING, J. E., JR. 1939. The relation of some observations upon predation to theories of protective coloration. *Condor*, 41: 100–111.

DARLING, F. F. 1937. *A Herd of Red Deer. A Study in Animal Behavior.* Oxford Univ. Press, London. 215 pp.

——. 1939. *Bird Flocks and the Breeding Cycle.* University Press, Cambridge. 124 pp.

DARWIN, C. 1872. *The Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.* 6th Ed. John Murray, London. 458 pp.

DAVIS, D. E. 1941. The relation of abundance to territorialism in tropical birds. *Bird Banding*, 12: 93–97.

——. 1942. The phylogeny of social nesting habits in the Crotophaginae. *Quart. Rev. Biol.*, 17: 115–134.

DAVIS, W. B. 1938. A heavy concentration of *Cryptotis*. *J. Mammal.*, 19: 499–500.

DAVISON, V. E. 1940. An 8-year census of lesser prairie chickens. *J. Wildlife Mangt.*, 4: 55–62.

DELACOUR, J. 1944. Government refuges are saving the trumpeter swan. *Animal Kingdom*, 47: 130–136.

DEMAY, I. S. 1942. An avifauna from Indian kitchen middens at Buena Vista Lake, California. *Condor*, 44: 228–230.

DICE, L. R., and P. M. BLOSSOM. 1937. Studies of mammalian ecology in southwestern North Ameri-

ca with special attention to the colors of desert mammals. *Publ. Carneg. Instn.*, 485. 129 pp.

DIXON, J. S. 1938. Birds and mammals of Mount McKinley National Park Alaska. *Fauna natl. Parks U. S., Fauna Ser.*, 3. 236 pp.

DOBIE, J. F. 1941. *The Longhorns*. Little, Brown, Boston. 388 pp.

DOTY, R. E. 1938. The prebaited feeding-station method of rat control. *Hawaii. Planters Rec.*, 43: 39–76.

EADIE, W. R. 1944. The short-tailed shrew and field mouse predation. *J. Mammal.*, 25: 359–364.

EDDY, S., and K. D. CARLANDER. 1940. The effect of environmental factors upon the growth rates of Minnesota fishes. *Proc. Minn. Acad. Sci.*, 8: 14–19.

EDMINSTER, F. C. 1938. Productivity of the ruffed grouse in New York. *Trans. N. Amer. Wildlife Conf.*, 3: 825–833.

——. 1939. The effect of predator control on ruffed grouse populations in New York. *J. Wildlife Mangt.*, 3: 345–352.

EINARSEN, A. S. 1939. Oregon's open season on antelope in 1938. *Trans. N. Amer. Wildlife Conf.*, 4: 216–220.

——. 1942. Specific results from ring-necked pheasant studies in the Pacific Northwest. *Trans. N. Amer. Wildlife Conf.*, 7: 130–146.

EKBLAW, W. E. 1921. The ecological relations of the Polar Eskimo. *Ecology*, 2: 132–144.

ELDER, W. H. 1945. The index of heron population, 1944. (Review of W. B. Alexander.) *Bird Banding*, 16: 146–147.

ELTON, C. 1935–37. Annual Reports. *Bur. Anim. Pop. Oxford Univ.* 48 pp. (1935–36) and 38 pp. (1936–37).

——. 1939. On the nature of cover. *J. Wildlife Mangt.*, 3: 332–338.

——. 1942. *Voles, Mice and Lemmings. Problems in Population Dynamics*. University Press, Oxford. 496 pp.

——, E. B. FORD, J. R. BAKER, and A. D. GARDNER. 1931. The health and parasites of a wild mouse population. *Proc. zool. Soc. Lond.*, 1931: 657–721.

——, and M. NICHOLSON. 1942. Fluctuations in numbers of the muskrat (*Ondatra zibethica*) in Canada. *J. Anim. Ecol.*, 11: 96–126.

EMLEN, J. T., JR. 1939. Seasonal movements of a low-density valley quail population. *J. Wildlife Mangt.*, 3: 118–130.

——. 1940. Sex and age ratios in survival of the California quail. *J. Wildlife Mangt.*, 4: 92–99.

ERICKSON, M. M. 1938. Territory, annual cycle and numbers in a population of wren-tits (*Chamaea fasciata*). *Univ. Calif. Publ. Zool.*, 42: 247–334.

ERRINGTON, P. L. 1932. Food habits of southern Wisconsin raptors. I. Owls. *Condor*, 34: 176–186.

——. 1937. Food habits of red foxes during a drought summer. *Ecology*, 18: 53–61.

——. 1940. Natural restocking of muskrat-vacant habitats. *J. Wildlife Mangt.*, 4: 173–185.

——. 1941a. Versatility in feeding and population maintenance of the muskrat. *J. Wildlife Mangt.*, 5: 68–89.

——. 1941b. An eight-winter study of central Iowa bob-whites. *Wilson Bull.*, 53: 85–102.

——. 1942. On the analysis of productivity in populations of higher vertebrates. *J. Wildlife Mangt.*, 6: 165–181.

——. 1943. An analysis of mink predation upon muskrats in northcentral United States. *Res. Bull. Iowa agric. Exp. Sta.*, 320: 797–924.

——. 1944. Ecology of the muskrat. *Iowa agric. Exp. Sta., Rept. agric. Res. Year Ending June 30, 1944*. I. Pp. 187–189.

——. 1945. Some contributions ot a fifteen-year local study of the northern bobwhite to a knowledge of population phenomena. *Ecol. Monog.*, 15: 1–34.

——, and F. N. HAMERSTROM, JR. 1936. The northern bob-white's winter territory. *Res. Bull. Iowa agric. Exp. Sta.*, 201: 301–443.

——, and ——. 1937. The evaluation of nesting losses and juvenile mortality of the ring-necked pheasant. *J. Wildlife Mangt.*, 1: 3–20.

——, F. HAMERSTROM, and F. N. HAMERSTROM, JR. 1940. The great horned owl and its prey in north-central United States. *Res. Bull. Iowa agric. Exp. Sta.*, 277: 757–850.

——, and T. G. SCOTT. 1945. Reduction in productivity of muskrat pelts on an Iowa marsh through depredations of red foxes. *J. agric. Res.*, 71: 137–148.

——, and H. L. STODDARD. 1938. Modifications in predation theory suggested by ecological studies of the bob-white quail. *Trans. N. Amer. Wildlife Conf.*, 3: 736–740.

EVANS, F. C. 1942. Studies of a small mammal population in Bagley Wood, Berkshire. *J. Anim. Ecol.*, 11: 182–197.

——, and R. HOLDENRIED. 1943. A population study of the Beechey ground squirrel in central California. *J. Mammal.*, 24: 231–260.

EVANS, L. T. 1936. A study of a social hierarchy in the lizard, *Anolis carolinensis*. *J. Genetic Psychol.*, 48: 88–111.

FALLIS, A. M. 1945. Population trends and blood parasites of ruffed grouse in Ontario. *J. Wildlife Mangt.*, 9: 203–206.

FISHER, L. W. 1939. Studies of the eastern ruffed grouse (*Bonasa umbellus umbellus*) in Michigan. *Tech. Bull. Mich. State Coll. agric. Exp. Sta.*, 166. 46 pp.

FOERSTER, R. E., and W. E. RICKER. 1941. The effect of reduction of predaceous fish on survival of young sockeye salmon at Cultus Lake. *J. Fish. Res. Bd. Can.*, 5: 315–336.

FORBUSH, E. H. 1929. *Birds of Massachusetts and other New England States. II. Land Birds from Bob-whites to Grackles.* Mass. Dept. Agric., Norwood, Mass. 461 pp.

FRIEDMANN, H. 1929. *The Cowbirds. A Study in the Biology of Social Parasitism.* C. C. Thomas, Springfield, Ill. 421 pp.

FRY, F. E. J. 1939. The position of fish and other higher animals in the economy of lakes. In *Problems of Lake Biology, Publ. Amer. Ass. Adv. Sci.*, 10. Pp. 132–142.

FURNISS, O. C. 1938. The 1937 waterfowl season in the Prince Albert District, central Saskatchewan. *Wilson Bull.*, 50: 17–27.

GAUSE, G. F. 1934. *The Struggle for Existence.* Williams and Wilkins, Baltimore. 160 pp.

——. 1935. Vérifications expérimentales de la théorie mathématique de la lutte pour la vie. *Actualités sci. industr.*, 277. 63 pp.

——. 1937. Experimental populations of microscopic organisms. *Ecology*, 18: 173–179.

——, N. P. SMARAGDOVA, and A. A. WITT. 1936. Further studies of interaction between predators and prey. *J. Anim. Ecol.*, 5: 1–18.

——, and A. A. WITT. 1935. Behavior of mixed populations and the problem of natural selection. *Amer. Nat.*, 69: 596–609.

GINSBERG, B., and W. C. ALLEE. 1942. Some effects of conditioning on social dominance and subordination in inbred strains of mice. *Physiol. Zool.*, 15: 485–506.

GIRARD, G. L. 1937. Life history, habits, and food of the sage grouse, *Centrocercus urophasianus* Bonaparte. *Univ. Wyo. Publ.*, 3. 56 pp.

GLADING, B. 1938. Studies on the nesting cycle of the California valley quail in 1937. *Calif. Fish and Game*, 24: 318–340.

GLADSTONE, H. S. 1937. The decrease in blackgame in Dumfriesshire. *Brit. Birds*, 31: 188–193.

GRANGE, W. B., and W. L. MCATEE. 1934. Improving the farm environment for wild life. *Fmrs' Bull. U. S. Dept. Agric.*, 1719. 61 pp.

GREELEY, J. R. 1932. The spawning habits of brook, brown and rainbow trout, and the problem of egg predators. *Trans. Amer. Fish. Soc.*, 62: 239–248.

GREEN, R. G., and C. A. EVANS. 1940a. Studies on a population cycle of snowshoe hares on the Lake Alexander area. I. Gross annual censuses, 1932–1939. *J. Wildlife Mangt.*, 4: 220–238.

——, and ——. 1940b. Studies on a population cycle of snowshoe hares on the Lake Alexander area. III. Effect of reproduction and mortality of young hares on the cycle. *J. Wildlife Mangt.*, 4: 347–358.

——, and C. L. LARSON. 1938. A description of shock disease in the snowshoe hare. *Amer. J. Hyg.*, 28: 190–212.

GRINNELL, J., J. S. DIXON, and J. M. LINSDALE. 1937. *Fur-bearing Mammals of California. Their Natural History, Systematic Status, and Relations to Man.* Univ. Calif. Press, Berkeley. 777 pp.

GROSS, A. O. 1928. The heath hen. *Mem. Boston Soc. Nat. Hist.*, 6: 487–588.

——. 1945. The present status of the great black-backed gull on the coast of Maine. *Auk*, 62: 241–256.

GUÉRIN, G. 1932. *La Vie des Chouettes. II. La Hulotte et son Regime.* Lussaud Frères, Fontenay-le-Comte. 242 pp.

GUNDERSON, H. 1944. Notes on a heavy Norway rat population. *J. Mammal.*, 25: 307–308.

HALL, E. R. 1927. An outbreak of house mice in Kern County, California. *Univ. Calif. Publ. Zool.*, 30: 189–203.

HAMERSTROM, F. N., JR. 1936. A study of the nesting habits of the ring-necked pheasant in northwest Iowa. *Iowa State Coll. J. Sci.*, 10. 173–203.

——. 1939. A study of Wisconsin prairie chicken and sharptailed grouse. *Wilson Bull.*, 51: 105–120.

HAMILTON, W. J., JR. 1937. The biology of microtine cycles. *J. agric. Res.*, 54. 779–790.

——. 1939. Observations on the life history of the red squirrel in New York. *Amer. Midl. Nat.*, 22. 732–745.

——. 1940a. Life and habits of field mice. *Sci. Mon.*, 50: 425–434.

——. 1940b. The biology of the smoky shrew (*Sorex fumeus fumeus* Miller). *Zoologica*, 25: 473–492.

——. 1941a. Reproduction of the field mouse *Microtus pennsylanicus* (Ord). *Cornell Univ. agric. Exp. Sta. Mem.*, 237. 23 pp.

——. 1941b. Notes on some mammals of Lee County, Florida. *Amer. Midl. Nat.*, 25: 686–691.

HAMMOND, M. C. 1940. Crow-waterfowl relationships on Federal refuges. *Trans. N. Amer. Wildlife Conf.*, 5: 398–404.

HANN, H. W. 1937. Life history of the oven-bird in southern Michigan. *Wilson Bull.*, 49: 145–237.

HARDY, R. 1945. The influence of types of soil upon the local distribution of some mammals in southwestern Utah. *Ecol. Monog.*, 15: 71–108.

HARPER, F. 1945. *Extinct and Vanishing Mammals of the Old World.* Special Publ. 12, Amer. Comm. Internatl. Wild Life Prot. Lord Baltimore Press, Baltimore. 850 pp.

HAUGEN, A. O. 1943. Management studies of the cottontail rabbit in southwestern Michigan. *J. Wildlife Mangt.*, 7: 102–119.

HEAPE, W. 1931. *Emigration, Migration and Nomadism.* Heffer, Cambridge. 369 pp.

HENDERICKSON, G. O. 1943. Mearns' cottontail investigations in Iowa. *Ames Forester*, 21: 59–74.

HERRICK, F. H. 1912. Organization of the gull colony. *Proc. 7th Internatl. Cong. Zool.* Pp. 156–158.

HERRINGTON, W. C. 1944. Factors controlling population size. *Trans. N. Amer. Wildlife Conf.*, 9: 250–263.

HIBBEN, F. C. 1937. A preliminary study of the mountain lion. *Univ. New Mexico Bull.*, 318. 59 pp.

HIBBERT-WARE, A. 1937. Report of the little owl inquiry, 1936–37. *Brit. Birds*, 31: 205–229.

——. 1940. An investigation of the pellets of the common heron (*Ardea cinerea cinerea*). *Ibis*, 1940: 433–450.

HICKEY, J. J. 1942. Eastern population of the duck hawk. *Auk*, 59: 176–204.

HICKS, L. E. 1935. A ten year study of a bird population in central Ohio. *Amer. Midl. Nat.*, 16: 177–186.

HOCHBAUM, H. A. 1944. *The Canvasback on a Prairie Marsh.* Amer. Wildlife Inst., Washington. 201 pp.

HOGBEN, L. 1931. Some biological aspects of the population problem. *Biol. Rev.*, 6: 163–180.

HOLMES, S. J. 1935. *The Biology of the Frog.* 4th Ed. Macmillan, New York. 386 pp.

HORN, E. E. 1938. Factors in the nesting losses of the California valley quail. *Trans. N. Amer. Wildlife Conf.*, 3: 741–746.

——. 1941. Some coyote-wildlife relationships. *Trans. N. Amer. Wildlife Conf.*, 6: 283–287.

HORNBERGER, F. 1938. Ueber die näturliche Regelung der ostpreussischen Storchübervölkerung durch Zugverluste und Brutausfall im Jahre 1937. *Beitr. Fort. Pfl. Biol. Vögel*, 14: 168–175. (Not seen; ref. *Bird Banding*, 10: 54, 1939.)

——. 1939. Zehn ostpreussische Storch-Zählungen. *Ornith. Monatsb.*, 47: 166–170. (Not seen; ref. *Bird Banding*, 11: 73, 1940.)

HOWARD, W. E., and J. T. EMLEN, JR. 1942. Intercovey social relationships in the valley quail. *Wilson Bull.*, 54: 162–170.

HOWELL, A. B. 1923. Periodic fluctuations in the numbers of small mammals. *J. Mammal.*, 4: 149–155.

HUBBS, C. L. 1944. An analysis of mink predation upon muskrats in north-central United States. (Review of P. L. Errington.) *Amer. Nat.*, 78: 176–177.

——, and R. W. ESCHMEYER. 1938. The improvement of lakes for fishing. A method of fish management. *Fish. Res. Bull. Mich. Dept. Conserv. Inst.*, 2. 233 pp.

HULL, A. V. 1939. Trumpeter swans, their management and preservation. *Trans. N. Amer. Wildlife Conf.*, 4: 378–382.

HUNTINGTON, E. 1931. The Matamek conference on biological cycles, 1931. *Science*, 74: 229–235.

HUNTSMAN, A. G. 1931. The maritime salmon of Canada. *Biol. Bd. Can. Bull.*, 21. 99 pp.

——. 1938. North American Atlantic salmon. *Cons. Perm. Internatl. Explor. Mer Rapp. Proc.-Verbaux*, 101B: 9–15.

——. 1941. Cyclical abundance and birds versus salmon. *J. Fish. Res. Bd. Can.*, 5: 227–235.

IMLER, R. H. 1945. Bullsnakes and their control on a Nebraska wildlife refuge. *J. Wildlife Mangt.*, 9: 265–273.

JOHNSON, F. W. 1943. Study quail population on Jornada Range. *New Mexico*, 21 (3): 24–25.

JOHNSON, R. A. 1938. Predation of gulls in murre colonies. *Wilson Bull.*, 50: 161–170.

KALABUKHOV, N. I. 1935. [On the causes of fluctuations in numbers of mouselike rodents.] *Zool. Zhur.*, 14: 209–249. (In Russian; summary in English.)

——, and V. V. RAEVSKII. 1933. [Methods for the study of certain problems in the ecology of mouse-like rodents.] *Rev. Microbiol., Saratov*, 12: 47–62. (In Russian; summary in German.) (Not seen; ref. Elton, 1942.)

KALMBACH, E. R. 1937. Crow-waterfowl relationships: based on preliminary studies on Canadian breeding grounds. *Circ. U. S. Dept. Agric.*, 433. 36 pp.

——. 1938. A comparative study of nesting waterfowl on the Lower Souris Refuge. *Trans. N. Amer. Wildlife Conf.*, 3: 610–623.

——. 1939. Nesting success: its significance in waterfowl reproduction. *Trans. N. Amer. Wildlife Conf.*, 4: 591–604.

——. 1940. Economic status of the English sparrow in the United States. *Tech. Bull. U. S. Dept. Agric.*, 711. 66 pp.

KENDEIGH, S. C. 1941. Territory and mating behavior of the house wren. *Ill. Biol. Monog.*, 18 (3): 1–120.

——. 1944. Measurement of bird populations. *Ecol. Monog.*, 14: 67–106.

——. 1945. Community selection by birds on the Helderberg Plateau of New York. *Auk*, 62: 418–436.

——, and S. P. BALDWIN. 1937. Factors affecting yearly abundance of passerine birds. *Ecol. Monog.*, 7: 91–124.

KING, R. T. 1937. Ruffed grouse management. *J. Forestry*, 35: 523–532.

KLIMOV, I. N. 1931. [On the biology of *Microtus* (*Stenocranius*) *gregalis* and the method of its control.] *Bull. Plant Prot. Siberia*, 1: 100–125. (In Russian.) (Not seen; ref. Elton, 1942.)

LACK, D. 1937. A review of bird census work and bird population problems. *Ibis*, 1937: 369–395.

LANG, H., W. EMEIS, E. SCHÜZ, und R. DROST. 1938. Weitere Angaben über Heimkehr-Verzögerung und Bestand des Weissen Storches 1937. *Vogelzug*, 9: 97–102.

LAY, D. W. 1945. The problem of undertrapping in muskrat management. *Trans. N. Amer. Wildlife Conf.*, 10: 75–78.

LEEDY, D. L., and L. E. HICKS. 1945. The pheasants in Ohio. In *The Ring-Necked Pheasant*. Editor, W. L. McAtee. Amer. Wildlife Inst., Washington. Pp. 57–130.

LEHMANN, V. W. 1946a. Bobwhite quail reproduction in southwestern Texas. *J. Wildlife Mangt.*, 10: 111–123.

——. 1946b. Mobility of bobwhite quail in southwestern Texas. *J. Wildlife Mangt.*, 10: 124–136.

LEOPOLD, A. 1933. *Game Management*. Scribners, New York. 481 pp.

——. 1943. Deer irruptions. *Trans. Wis. Acad. Sci., Arts and Letters*, 35: 351–366.

LEOPOLD, A. S. 1944. The nature of heritable wildness in turkeys. *Condor*, 46: 133–197.

LESLIE, P. H., and R. M. RANSON. 1940. The mortality, fertility and rate of natural increase of the vole (*Microtus agrestis*) as observed in the laboratory. *J. Anim. Ecol.*, 9: 27–52.

LEWIS, H. F. 1923. Additional notes on the birds of the Labrador Peninsula. *Auk*, 40: 135–137.

LOCKLEY, R. M. 1930. On the breeding-habits of the Manx shearwater, with special reference to its incubation- and fledging-periods. *Brit. Birds*, 23: 202–218.

——. 1938. The little owl inquiry and the Skokholm storm-petrels. *Brit. Birds*, 31: 278–279.

LORENZ, K. 1935. Der Kumpan in der Umwelt des Vogels. *J. Orn., Lps.*, 83: 137–214.

——. 1937. The companion in the bird's world. *Auk*, 54: 245–273.

LOW, J. B. 1945. Ecology and management of the redhead, *Nyroca americana*, in Iowa. *Ecol. Monog.*, 15: 35–69.

MACLULICH, D. A. 1937. Fluctuations in the numbers of the varying hare (*Lepus americanus*). *Biol. Ser. Univ. Toronto Studies*, 43. 136 pp.

MARSTON, M. A. 1942. Winter relations of bobcats to white-tailed deer in Maine. *J. Wildlife Mangt.*, 6: 328–337.

MATHESON, C. 1943. The grey wolf. *Antiquity*, 17: 11–18.

MAYALL, A. 1934. Numbers and destruction of broods of nightingales in Suffolk. *Brit. Birds.*, 28: 145–146.

MCATEE, W. L. 1932. Effectiveness in nature of the so-called protective adaptations in the animal kingdom, chiefly as illustrated by the food habits of Nearctic birds. *Smiths. Misc. Coll.*, 85 (7). 201 pp.

——. 1933. Rejoinder to papers on protective adaptations. *Proc. roy. ent. Soc., Lond.*, 81: 113–126.

——. 1936. The Malthusian principle in nature. *Sci. Mon.*, 42: 444–456.

——. 1937. Survival of the ordinary. *Quart. Rev. Biol.*, 12: 47–64.

MCCLURE, H. E. 1942. Mourning dove production in southwestern Iowa. *Auk*, 59: 64–75.

——. 1943. Ecology and management of the mourning dove, *Zenaidura macroura* (Linn.), in Cass County, Iowa. *Res. Bull. Iowa agric. Exp. Sta.*, 310: 355–415.

MCNEILE, J. H. 1941. Conditions in northern breeding areas of wildfowl. Spitzbergen. In *Factors Affecting the General Status of Wild Geese and Wild Duck* (*International Wildfowl Inquiry, Vol. I*). University Press, Cambridge. Pp. 23–27.

MENDALL, H. L., and C. M. ALDOUS. 1943. *The Ecology and Management of the American Woodcock*. Maine Coop. Wildlife Res. Unit, Orono. 201 pp.

MIDDLETON, A. D., and H. CHITTY. 1937. The food of adult partridges, *Perdix perdix* and *Alectoris rufa*, in Great Britain. *J. Anim. Ecol.*, 6: 322–336.

MILLER, R. C. 1922. The significance of the gregarious habit. *Ecology*, 3: 122–126.

MOREAU, R. E., and W. M. MOREAU. 1938. The comparative breeding ecology of two species o *Euplectes* (bishop birds) in Usambara. *J. Anim. Ecol.*, 7: 314–327.

MOSBY, H. S., and C. O. HANDLEY. 1943. *The Wild Turkey in Virginia: Its Status, Life History and Management*. Commission of Game and Inland Fisheries, Richmond. 281 pp.

MOTTLEY, C. MCC. 1940. The production of rainbow trout at Paul Lake, British Columbia. *Trans. Amer. Fish. Soc.*, 69: 187–191.

——. 1941. The effect of increasing the stock in a lake on the size and condition of rainbow trout. *Trans. Amer. Fish. Soc.*, 70: 414–420.

MUNRO, J. A. 1939a. The relation of loons, Holboell's grebes, and coots to duck populations. *J. Wildlife Mangt.*, 3: 339–344.

——. 1939b. Studies of waterfowl in British Columbia. Barrow's golden-eye, American golden-eye. *Trans. roy. Can. Inst.*, 22, Pt. 2: 259–318.

MUNRO, J. A. 1941. Studies of waterfowl in British Columbia. Greater scaup duck, lesser scaup duck. *Can. J. Res.*, 19: 113–138.

——. 1943. Studies of waterfowl in British Columbia. Mallard. *Can. J. Res.*, 21: 223–260.

MURIE, A. 1934. The moose of Isle Royale. *Misc. Publ. Mus. Zool. Univ. Mich.*, 25. 44 pp.

——. 1936. Following fox trails. *Misc. Publ. Mus. Zool. Univ. Mich.*, 32. 45 pp.

——. 1940. Ecology of the coyote in the Yellowstone. *Fauna natl. Parks U. S., Fauna Ser.*, 4. 202 pp.

——. 1944. The wolves of Mount McKinley. *Fauna natl. Parks U. S., Fauna Ser.*, 5. 238 pp.

MURIE, O. J. 1935. Food habits of the coyote in Jackson Hole, Wyo. *Circ. U. S. Dept. Agric.*, 362. 24 pp.

——. 1944. Our big game in winter. *Trans. N. Amer. Wildlife Conf.*, 9: 173–176.

MURPHY, R. C. 1936. *Oceanic Birds of South America*. Amer. Mus. Nat. Hist., New York. 1245 pp.

NAUMOV, N. P. 1936. [Reproduction and mortality in the common vole (*Microtus arvalis* Pall.).] *Misc. Works Zool. Inst. Moscow State Univ.*, No. 3: 144–170. (In Russian; summary in English.) (Not seen; ref. Elton, 1942.)

——. 1937a. [On the distribution of muriform rodents (*Microtus arvalis* Pall., *Microtus socialis* Pall., *Lagurus lagurus* Pall., *Mus musculus hortulanus* Noram.) at different habitats.] *Sci. Rep. Moscow State Univ.*, 13: 3–38. (In Russian; summary in English.)

——. 1937b. [On the comparative intensity of reproduction and mortality of the field-vole and steppe-lemming.] *Zool. Zhur.*, 16: 336–361. (In Russian; summary in English.)

——. 1939. [Ecological characters in steppe mice and voles.] *Zool. Zhur.*, 18: 711–732. (In Russian; summary in English.)

——. 1945. [Geographical variability of fluctuations in numbers and the evolution.] *J. Gen. Biol.*, 6: 37–52. (In Russian; summary in English.)

NEEDHAM, P. R., J. W. MOFFETT, and D. W. SLATER. 1945. Fluctuations in wild brown trout populations in Convict Creek, California. *J. Wildlife Mangt.*, 9: 9–25.

——, and D. W. SLATER. 1944. Survival of hatchery-reared brown and rainbow trout as affected by wild trout populations. *J. Wildlife Mangt.*, 8: 22–36.

NICE, M. M. 1933–34. Zur Naturgeschichte des Singnammers. *J. Orn., Lpz.*, 81: 552–595; 82: 1–96.

——. 1937. Studies in the life history of the song sparrow. I. A population study of the song sparrow. *Trans. Linn. Soc. N. Y.*, 4. 247 pp.

——. 1941. The role of territory in bird life. *Amer. Midl. Nat.*, 26: 441–487.

——. 1943. Studies in the life history of the song sparrow. II. The behavior of the song sparrow and other passerines. *Trans. Linn. Soc. N. Y.*, 6. 329 pp.

NICHOLSON, A. J. 1933. The balance of animal populations. *J. Anim. Ecol.* 2: 132–178.

——, and V. A. BAILEY. 1935. The balance of animal populations. I. *Proc. zool. Soc. Lond.*, 1935: 551–598.

NOBLE, G. K. 1931. *The Biology of the Amphibia*. McGraw-Hill, New York. 577 pp.

——. 1938. Sexual selection among fishes. *Biol. Rev.*, 13: 133–158.

——, and H. T. BRADLEY. 1933. The mating behavior of the lizards; its bearing on the theory of sexual section. *Ann. N. Y. Acad. Sci.*, 35: 25–100.

PALMER, R. S. 1938. Tern mortality along the Maine coast. *Bird Banding*, 9: 117–123.

PALMGREN, P. 1932. Zur Biologie von *Regulus r. regulus* (L.) und *Parus atricapillus borealis* Selys. Eine vergleichend-ökologische Untersuchung. *Acta. Zool. Fennica*, 14. 113 pp.

PARK, T. 1941. The laboratory population as a test of a comprehensive ecological system. *Quart. Rev. Biol.*, 16: 274–293, 440–461.

PEARL, R. 1925. *The Biology of Population Growth*. Knopf, New York. 260 pp.

——. 1932. The influence of density of population upon egg production in *Drosophila melanogaster*. *J. exp. Zool.*, 63: 57–84.

——. 1937. On biological principles affecting populations: human and other. *Amer. Nat.*, 71: 50–68.

——, and S. L. PARKER. 1922. On the influence of density of population upon the rate of egg production in *Drosophila*. *Proc. nat. Acad. Sci., Wash.*, 8: 212–219.

PELKWIJK, J. J. TER, und N. TINBERGEN. 1937. Eine reizbiologische Analyse einiger Verhaltensweisen von *Gasterosteus aculeatus* L. *Z. Tierpsychol.*, 1: 193–200.

PHILLIPS, J. C. 1922. *A Natural History of the Ducks. I.* Houghton Mifflin, Boston. 264 pp.

——, and F. C. LINCOLN. 1930. *American Waterfowl. Their Present Situation and the Outlook for their Future*. Houghton Mifflin, Boston. 312 pp.

PIRNIE, M. D. 1935. *Michigan Waterfowl Management*. Mich. Dept. Conserv., Lansing. 328 pp.

POPHAM, E. J. 1942. Further experimental studies of the selective action of predators. *Proc. zool. Soc. Lond.*, A, 112: 105–117.

POTTER, J. K. 1915. Egg and nestling destruction. *Cassinia*, 19: 30–32.

PRESNALL, C. C. 1943. Wildlife conservation as affected by American Indian and Caucasian concepts. *J. Mammal.*, 24: 458–464.

PRICE, M. P. 1935. Notes on population problems and territorial habits of chiffchaffs and willow warblers. *Brit. Birds*, 29: 158–166.

RANSON, R. M. 1934. The field vole (*Microtus*) as a laboratory animal. *J. Anim. Ecol.* 3: 70–76.

RASMUSSEN, D. I. 1941. Biotic communities of Kaibab Plateau, Arizona. *Ecol. Monog.*, 11: 229–275.

RETZLAFF, E. G. 1938. Studies in population physiology with the albino mouse. *Biol. Gen.*, 14: 238–265.

RICKER, W. E. 1937. The food and the food supply of sockeye salmon (*Oncorhynchus nerka* Walbaum) in Cultus Lake, British Columbia. *J. Biol. Bd. Can.*, 3: 450–468.

——. 1941. The consumption of young sockeye salmon by predaceous fish. *J. Fish. Res. Bd. Can.*, 5: 293–313.

——. 1945a. Natural mortality among Indiana bluegill sunfish. *Ecology*, 26: 111–121.

——. 1945b. Abundance, exploitation and mortality of the fishes in two lakes. *Invest. Ind. Lakes and Streams*, 2: 345–448.

RITER, W. E. 1941. Predator control and wildlife management. *Trans. N. Amer. Wildlife Conf.*, 6: 294–299.

ROBERTS, T. S. 1932. *The Birds of Minnesota.* Univ. Minn. Press, Minneapolis. 821 pp.

ROEBUCK, A. 1938. The rook in the rural economy of the Midlands. *Ann. appl. Biol.*, 25: 215–218.

ROLLINGS, C. T. 1945. Habits, foods and parasites of the bobcat in Minnesota. *J. Wildlife Mangt.*, 9: 131–145.

ROSTRAND, J. 1934. *Toads and Toad Life.* Methuen, London. 192 pp.

SALYER, J. C., II, and K. F. LAGLER. 1940. The food and habits of the American merganser during winter in Michigan, considered in relation to fish management. *J. Wildlife Mangt.*, 4: 186–219.

SCHORGER, A. W. 1944. The quail in early Wisconsin. *Trans. Wis. Acad. Sci., Arts and Letters*, 36: 77–103.

SCHÜZ, E. 1936. The white stork as a subject of research. *Bird Banding*, 7: 99–107.

——. 1938. Über Biologie und Ökologie des weissen Storchs (*Ciconia c. ciconia*). *Proc. 8th Int. Orn. Cong.* Pp. 577–591.

SCOTT, T. G. 1943. Some food coactions of the northern plains red fox. *Ecol. Monog.*, 13: 427–479.

——, and L. F. SELKO. 1939. A census of red foxes and striped skunks in Clay and Boone Counties, Iowa. *J. Wildlife Mangt.*, 3: 92–98.

SEMPER, K. 1880. *Die natürlichen Existenzbedingungen der Thiere.* Internatl. Wissenschaftliche Bibliothek, 39. 296 pp. (Not seen; ref. Van Oosten, 1944.)

SERVENTY, D. L. 1938. The feeding habits of cormorants in south-western Australia. *Emu*, 38: 293–316.

SETON, E. T. 1929. *Lives of Game Animals.* 4 vols. Doubleday, Doran, New York.

SEVERTZOFF, S. A. 1934. On the dynamics of populations of vertebrates. *Quart. Rev. Biol.*, 9: 409–437.

——. [Sewertzoff]. 1935. [Zur Frage der Vermehrungsbiologie der Tetraoniden im Staatlichen Waldschutzgebiet Baschkiriens.] *Zool. Zhur.*, 14: 371–396. (In Russian; summary in German.)

SHELDON, C. 1930. *The Wilderness of Denali.* Scribner's, New York. 412 pp.

SHELFORD, V. E. 1943. The abundance of the collared lemming (*Dicrostonyx groenlandicus* (Tr.) var. *richardsoni* Mer.) in the Churchill area, 1929 to 1940. *Ecology*, 24: 472–484.

SHERMAN, A. R. 1925. Down with the house wren boxes. *Wilson Bull.*, 37: 5–12.

SILLIMAN, R. P., and F. N. CLARK. 1945. Catch per-unit-of-effort in California waters of the sardine (*Sardinops caerulea*) 1932–1942. *Fish. Bull. Calif. Div. Fish and Game.*, 62. 76 pp.

SMITH, E. V. and H. S. SWINGLE. 1943. Results of further experiments on the stocking of fish ponds. *Trans. N. Amer. Wildlife Conf.*, 8: 168–179.

SMITH, H. M. 1943. Size of breeding populations in relation to egg-laying and reproductive success in the eastern red-wing (*Agelaius p. phoeniceus*). *Ecology*, 24: 183–207.

SOOTER, C. A. 1941. Ecology and management of the American coot *Fulica americana americana* Gmelin. Doctoral Thesis, Library, Iowa State College. Abst. *Iowa State Coll. J. Sci.*, 17: 126–128, 1942.

SOPER, J. D. 1919 Notes on Canadian weasels. *Canad. Field Nat.*, 33: 43–47.

——. 1930. *The Blue Goose.* Canada Dept. Interior, Ottawa. 64 pp.

——. 1937. Notes on the beavers of Wood Buffalo Park, Alberta. *J. Mammal.*, 18: 1–13.

——. 1941. History, range, and home life of the northern bison. *Ecol. Monog.*, 11: 347–412.

SOUTHERN, H. N. 1940. The ecology and population dynamics of the wild rabbit (*Oryctolagus cuniculus*). *Ann. appl. Biol.*, 27: 509–526.

SPERRY, C. C. 1941. Food habits of the coyote. *Wildlife. Res. Bull. U. S. Dept. Int.*, 4. 70 pp.

STEINFATT, O. 1938. Das Brutleben der Waldschnepfe. *J. Orn., Lpz.*, 86: 379–424.

STUEWER, F. W. 1943. Raccoons: their habits and management in Michigan. *Ecol. Monog.*, 13: 203–258.

STODDARD, H. L. 1931. *The bobwhite Quail. Its Habits, Preservation and Increase.* Scribner's, New York. 559 pp.

STODDARD, H. L., and E. V. KOMAREK. 1941. Predator control in southeastern quail management. *Trans. North Amer. Wildlife Conf.*, 6: 288–293.

STORER, T. I. 1932. Factors influencing wild life in California, past and present. *Ecology*, 13: 315–327.

——. 1937. The muskrat as native and alien. *J. Mammal.*, 18: 443–460.

SUMNER, E. L., Jr. 1935. A life history study of the California quail, with recommendations for conservation and management. *Calif. Fish and Game*, 21: 165–256, 277–342.

SUMNER, F. B. 1932. Genetic, distributional, and evolutionary studies of the subspecies of deer mice (*Peromyscus*). *Bibliog. Genetica*, 9: 1–106.

SWINGLE, H. S., and E. V. SMITH. 1940. Experiments on the stocking of fish ponds. *Trans. N. Amer. Wildlife Conf.*, 5: 267–276.

——, and ——. 1943. Effect of management practices on the catch in a 12-acre pond during a 10-year period. *Trans. N. Amer. Wildlife Conf.*, 8: 141–155.

TAYLOR, W. P. 1935. Ecology and life history of the porcupine (*Erethizon epixanthum*) as related to the forests of Arizona and the southwestern United States. *Univ. Ariz. Bull.*, 6(5). 177 pp.

THOMPSON, D. H. 1941. The fish production of inland streams and lakes. In *A Symposium on Hydrobiology*. Univ. Wis. Press, Madison. Pp. 206–217.

——, and F. D. HUNT. 1930. The fishes of Champaign County. A study of the distribution and abundance of fishes in small streams. *Bull. Ill. nat. Hist. Surv.*, 19. 101 pp.

THOMPSON, W. R. 1939. Biological control and the theories of the interactions of populations. *Parasitology*, 31: 299–388.

TINBERGEN, N. 1933. Die Ernährungsökologischen Beziehungen zwischen *Asio otus otus* L. und ihren Beutetieren, inbesondre den Microtus-Arten. *Ecol. Monog.*, 3: 443–492.

——. 1936. The function of sexual fighting in birds; and the problem of the origin of "territory." *Bird Banding*, 7: 1–8.

TROWBRIDGE, A. H., and H. L. WHITAKER. 1934. Some observations on birds in southeastern Oklahoma. *Wilson Bull.*, 46: 240–242.

ULBRICH, J. 1930. *Die Bisamratte; Lebensweise, Gang ihrer Ausbreitung in Europa, wirtschaftliche Bedeutung und Bekämpfung*. Heinrich, Dresden. 137 pp.

VAN OOSTEN, J. 1944. Factors affecting the growth of fish. *Trans. N. Amer. Wildlife Conf.*, 9: 177–183.

VESTAL, E. H. 1938. Biotic relations of the wood rat (*Neotoma fuscipes*) in the Berkeley Hills. *J. Mammal.*, 19: 1–36.

VINOGRADOV, B. S. 1934. [*Materials for the study of the dynamics of the fauna of muriform rodents in the U. S. S. R.*] People's Commissariat Agric., Ass'n Pest and Disease Control U. S. S. R., Leningrad. 63 pp. (In Russian; summary in English.)

VOGT, W. 1942. Informe sobre las aves guaneras. *Bol. Comp. Admin. del Guano*, 18(3). 132 pp.

VOLTERRA, V. 1931. Variations and fluctuations of the number of individuals in animal species living together. In Chapman (1931): 409–448.

——, et U. D'ANCONA. 1935. Les associations biologiques au point de vue mathematique. *Actualités sci. indust.*, 243. 97 pp.

VORHIES, C. T., and W. P. TAYLOR. 1940. Life history and ecology of the white-throated wood rat, *Neotoma albigula albigula* Hartley, in relation to grazing in Arizona. *Tech. Bull. Univ. Ariz.*, 86: 453–529.

WARFEL, H. E., and D. MERRIMAN. 1944. Studies on the marine resources of southern New England. I. An analysis of the fish population of the shore zone. *Bull. Bingham Ocean. Coll.*, 9(2). 91 pp.

WARWICK, T. 1940. A contribution to the ecology of the musk-rat (*Ondatra zibethica*) in the British Isles. *Proc. zool. Soc. Lond*, A, 110: 165–201.

WHELAN, R. V. 1939. Vole plague at Smoky Falls, Ontario. *Canad. Field Nat.*, 53: 53–55.

WHITE, H. C. 1937. Local feeding of kingfishers and mergansers. *J. Biol. Bd. Can.*, 3: 323–338.

——. 1939. Bird control to increase the Margaree River salmon. *Bull. Fish. Res. Bd. Can.*, 58. 30 pp.

WHITEHEAD, A. N. 1925. *Science and the Modern World*. Macmillan, New York. 296 pp.

WILLIAMS, A. B. 1936. The composition and dynamics of a beech-maple climax community. *Ecol. Monog.*, 6: 317–408.

WILLIAMS, C. S., and W. H. MARSHALL. 1938. Duck nesting studies, Bear River Migratory Bird Refuge, Utah, 1937. *J. Wildlife Mangt.*, 2: 29–48.

WORTH, C. B. 1937. A problem and a plan relative to the study of bird diseases. *Bird Banding*, 8: 109–113.

WORTHINGTON, E. B. 1937. On the evolution of fish in the great lakes of Africa. *Int. Rev. Hydrobiol.*, 35: 304–317.

WRIGHT, A. H. 1932. *Life Histories of the Frogs of Okefinokee Swamp, Georgia. North American Salientia (Anura) No. 2*. Macmillan, New York. 497 pp.

WRIGHT, S. 1932. The roles of mutation, inbreeding, crossbreeding, and selection in evolution. *Proc. 6th Int. Cong. Gen.*, 1: 356–366.

——. 1940. Breeding structure of populations in relation to speciation. *Amer. Nat.*, 74: 232–248.

WRIGHT, S. 1945. Tempo and mode in evolution: a critical review. (Review of G. G. Simpson.) *Ecology*, 26: 415–419.

WRITERS, VARIOUS. 1927. Notes on the habits of the house wren. *Wilson Bull.*, 39: 232–235.

YEATTER, R. E. 1934. The Hungarian partridge in the Great Lakes Region. *Bull. Univ. Mich. Sch. Forest. and Conserv.*, 5. 92 pp.

——. 1943. The prairie chicken in Illinois. *Bull. Ill. nat. Hist. Surv.*, 22: 375–416.

YOCUM, C. F. 1943. The Hungarian partridge *Perdix perdix* Linn. in the Palouse Region, Washington. *Ecol. Monog.*, 13: 167–202.

YOUNG, S. P., and E. A. GOLDMAN. 1944. *The Wolves of North America*. Amer. Wildlife Inst., Washington. 636 pp.

ZETEK, J. 1917. The ecology of bubonic plague. *Ann. ent. Soc. Amer.*, 10: 198–206.

THE EUGLENOID FLAGELLATES

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PROBABLY no other order of free-living Protista has received such widespread attention as the Euglenida. This is largely the result of the unique taxonomic position of the order. The obvious plant-like characteristics of some genera (e.g. *Euglena*) and the obvious animal-like characteristics of others (e.g., *Peranema*) require that the euglenoid flagellates be considered by both botanists and zoologists. The absence of any clear line of demarcation between green and colorless forms makes it seem inadvisable to assort the organisms among the plant and animal kingdoms and thereby separate, on the basis of obviously arbitrary criteria, the members of a closely related although superficially heterogeneous group.

The purpose of the present paper is to discuss the general biology of the euglenoids and to cite enough references to the widely scattered literature so that available detailed information may easily be found. The most useful general treatments of the group are those of Smith (1933), Dangeard (1933), Fritsch (1935), and Kudo (1946).

THE ORDER EUGLENIDA

The euglenoids consist of both green and colorless flagellates, usually with one or two flagella which arise from the invaginated anterior region of the cell known as the gullet. Chloroplasts when present are almost pure green, and all chlorophyll-bearing species possess a red stigma. Metaplasmic reserve materials consist of paramylum.

OCCURRENCE: CONDITIONS WHICH AFFECT GROWTH

Factors which control the occurrence of euglenoids are, in general, the same factors which control growth of the organisms. Therefore, a thorough understanding of their ecology involves a thorough understanding of their physiology, especially of their nutrition and of the effects of temperature, pH, and oxygen concentration upon them. The relationships of these factors are discussed by Jahn (1934) and Lackey (1938b).

Euglenoids are found most abundantly in small freshwater pools rich in organic matter. This is especially true of the genera *Euglena*, *Phacus*, and *Trachelomonas* which are often found in sufficient quantities to color the water (green or red for *Euglena*, green for *Phacus*, and yellow-brown for *Trachelomonas*), especially if the temperature is above 25°C. (e.g., Senior-White, 1928; Sands, 1934; earlier literature cited by Naumann, 1922). Euglenoids are sometimes the dominant forms on the surface of thick bottom deposits of ponds, especially if the organic content is high (Lund, 1942).

The euglenoids are sometimes stated to be indicators of sewage pollution. However, Lackey and Smith (1940) have pointed out that many species are abundant where pollution is absent. When euglenoids are found in polluted streams the maximum number is many miles downstream from the peak of sewage pollution, in the region where the water is becoming clarified but is still high in dissolved organic matter. The genera *Euglena*, *Phacus*, and *Trachelomonas* are very common in the sewage polluted Scioto River below Cincinnati, Ohio (Lackey, 1939a), but not in the polluted Duck and Cumberland rivers below Columbia (Tenn.) and Nashville (Tenn.), respectively (Lackey and Smith, 1940). The presence of large numbers of euglenoids is evidence of a high dissolved organic content but not necessarily of its sewage origin. Many euglenoids are tolerant of distillery wastes (Lackey, 1942).

Some species of *Euglena* inhabit damp mud along the banks of rivers, estuaries, and salt marshes where they may color the mud over wide areas, and the appearance of the color sometimes shows a periodicity related to the tides and light intensity (Bracher, 1919, 1929; Gard, 1922; Fraser, 1932; Carter, 1933). The ecological distribution of various species of Euglena is discussed by Günther (1928), and the types of habitat (catharobic, oligo-, meso-, or polysaprobic) for many species are listed by Fair and Whipple (1927).

Certain species of *Euglena* (e.g., *E. gracilis*) are

able to grow over a very wide pH range (Jahn, 1931; Alexander, 1931) while others (*E. deses* and *E. anabaena*) are able to grow only within a very restricted pH range (Dusi, 1930; Hall, 1933a). *Euglena mutabilis* is the most common organism in water-filled coal mine pits (pH 1.8–3.9, Lackey, 1938a, 1939b) and exhibits maximal growth only in an acid medium (von Dach, 1943). *Lepocinclis ovum* has also been observed in large numbers in a mine pit at a pH 2.5 (Lackey, 1939b). Wermel (1924a) has described several euglenoids from acid (pH 2 to 4) peat bogs. *Astasia* sp. and *Khawkinea halli* grow most rapidly in an almost neutral medium (Schoenborn, 1936), but *K. halli* also grows well over the pH range 4.0 to 8.0 (Elliott, 1938).

Cysts of Euglena have been reported from tree bark, (Briscoe, 1939) and moist or dried soil (many observers, e.g., Günther, 1928; Johnson, 1944).

The saprophytic colorless species are seldom found in large numbers, but they grow best when a considerable amount of putrefaction is present (e.g., Scioto River, Lackey, 1938a). Pringsheim (1942 and earlier) has been very successful in culturing them in species pure cultures in tubes containing garden soil, $CaCO_3$, and a suitable organic material such as starch. *Peranema* and other holozoic euglenoids, of course, require the presence of particulate food (diatoms, algae, debris).

Sessile species grow upon algae, plant debris, and small crustaceans. One species of *Euglena* may be attached to *Volvox* colonies. There are a few euglenoids which live in flatworms, oligochaetes, copepods, gastrotrichs, rotifers, nematodes, amphibians, and the eggs of nudibranch molluscs (literature, Kirby, 1941a). The endozoic species are usually considered to be distinct from those which are free-living, and Janda and Jírovec (1937) were not able to infect molluscs, crustaceans, or insects with a colorless strain of *Euglena gracilis*.

Two genera (*Euglenamorpha* and *Hegneria*) have been found only in the intestines of amphibia, usually frog or toad tadpoles (literature, Wenrich, 1935; Kirby, 1941a). There are two varieties (or species) of *Euglenamorpha*, one green with three flagella and a stigma, and the other colorless with two to six flagella and no stigma. The colorless organisms with the more numerous flagella may be division stages. However, *Hegneria*, which is very similar to the colorless species of *Euglenamorpha*, usually has seven (sometimes six) flagella, and no triflagellate stages or chlorophyll-bearing species are known. Wenrich has pointed out that the loss of stigma and chlorophyll and the increase in number of flagella may be considered as adaptations to the endozoic mode of life.

Numerous genera have been reported from brackish water (*Euglena*, Wermel, 1924b; van Goor, 1925, Schiller, 1925, Biecheler, 1937, Carter, 1937; *Eutreptia*, Steuer, 1904, van Goor, 1925, Schiller, 1925; *Trachelomonas*, *Phacus*, and *Khawkinea*, van Goor, 1925) and from salt water (*Euglena*, Schiller, 1925, Lackey, 1936; *Heteronema*, Lemmermann, 1906, Kahl, 1928, Lackey, 1936; *Lepocinclis*, *Phacus*, *Colacium*, Lemmermann, 1906; *Astasia*, *Trachelomonas*, *Eutreptia*, *Euglenopsis*, *Urceolus*, *Peranema*, *Petalomonas*, *Tropidoscyphus*, *Distigma*, *Notosolenus*, *Anisonema*, *Dinema*, Lackey, 1936). *Euglena* has also been reported from the Great Salt Lake (Jones, 1944). The genera *Ploeotia*, *Eutreptiella*, *Chloranima*, *Chlorachne*, *Klebsiella*, *Triangulomonas*, *Peranemopsis* and *Clautriavia* have apparently been described only from salt or brackish water (Walton, 1915; Schiller, 1925; Pascher, 1931; Lackey, 1940a).

The occurrence of the same species in both fresh and salt water naturally leads to the question of adaptability to high osmotic pressures. Finley (1930) found that *Euglena oxyuris*, *E. terricola*, *E.* sp., and *Phacus pleuronectes* can be acclimated to full strength sea water, *Entosiphon* to 40 per cent, and two endozoic species of *Khawkinea* to 80 per cent. For direct transfer the tolerances vary from 5 to 40 per cent for the same species. Loefer (1939) found that *Astasia* remains viable in 100 per cent sea water, but that motility is lost above 40 per cent. He also found that *Euglena gracilis* lives and grows only in concentrations below 40 per cent. Loefer found that the euglenoids (in contrast to ciliates and other flagellates) do not exhibit a gradual adaptation to higher concentrations but are almost as resistant on the first transfer as on the thirteenth (two months or more later).

Almost all euglenoid genera have been reported from soil samples (Sandon, 1927; Singh, 1941) and Lackey (1940b) has identified forty-two species belonging to fifteen genera from tree holes.

Few studies of the direct effect of temperature on growth have been made. Jahn (1935) found that the optimum temperature of *Euglena gracilis* in a peptone medium in darkness is 10°C. and that an increasing percentage of division cysts occurs above 15°C. When sodium acetate is present, the optimal temperature is 23°C., a point approaching the optimum in the light. The resistance to high temperatures varies with pH. *E. gracilis* is killed

twice as rapidly by exposure to 40°C. when the pH is 5.0 as when it is 4.0 or 8.0 (Jahn, 1933a).

Very little is known about the oxygen requirements of euglenoids. Lackey (1932) found that a number of genera (*Distigma*, *Entosiphon*, *Euglena gracilis*, *Heteronema*, *Rhabdomonas*, *Peranema*, *Notosolenus*, and *Petalomonas*) were present under anaerobic conditions in sewage digestion tanks but only in small numbers.

Von Dach (1940) found that *Astasia* grew almost as well under semi-anaerobic conditions as at atmospheric oxygen tension, in spite of the fact that the organism may consume considerable quantities of oxygen (von Dach, 1942). Lindeman (1942) found that *Euglena deses*, *Heteronema acus*, *H.* sp., *Phacus pyrum*, and *Trachelomonas* survived anaerobic conditions for 30 days at 0–5°C., but at 10°C. only *Heteronema acus* survived. The occurrence of anaerobiosis is discussed by von Brand (1944).

Apparently no quantitative studies of the effect of visible light have been made, but the growth of most chlorophyll-bearing species is obviously enhanced by illumination. Swann and del Rosario (1931, 1932) studied the toxic effects of ultraviolet irradiation and of alpha particles. The toxic photodynamic action of certain dyes and the counter effect of Germanin (Bayer 205) against the photodynamic effect and also against ultraviolet radiation have been described by Jírovec (1934a) and Jírovec and Vácha (1934a, 1934b).

Fossil euglenoids are apparently rare. However, Bradley (1929) reported *Phacus caudata* from a gelatinous compacted lithified lacustrine ooze. The name "*Trachelomonas*" has been erroneously applied to fossil Chrysomonads which have a siliceous skeleton (Deflandre, 1934a; 1935).

CELL EXTERIOR

The exterior of the cell is differentiated into a periplast or pellicle, which may be rigid, so that the cell has a fixed shape (e.g., *Phacus*, *Rhabdomonas*, *Menoidium*); or may be quite flexible, so that the shape may change considerably during "metabolic movements" (e.g., *Euglena gracilis*, *E. deses*, *Distigma proteus*); or may be only slightly flexible, so that metabolic movements are minimized (e.g., *E. trisulcata*, *E. tripteris*). In some species the pellicle is smooth or very finely striated (e.g., *Astasia torta*, *Distigma sennii*), and in others it is longitudinally or spirally striated (e.g., *Phacus*), or with spiral ridges (e.g., *Phacus pyrum*), or with spirally or longitudinally arranged punctae which may be simple (e.g., *Euglena spirogyra*, *Phacus monilata*) or complex in structure (e.g., *E. fusca*, Lefèvre, 1934). In *Euglena rubra*, but not in most other species of *Euglena*, the pellicle is separated from the protoplast by Noland's fixative (Johnson, 1942).

In some species of *Phacus* (*P. pleuronectes* and *P. longicauda* but not *P. caudata* var. *polonica*, or *P. pusilla*) there is, in addition to the longitudinal striae a number of closely spaced cross striations. These striations of *Phacus*, as well as other surface sculpturing of *Rhabdomonas*, *Euglena*, *Entosiphon* and *Anisonema* have been described by Jírovec (1929) and Klein (1930) as a "silverline" system. The identity of the silverline system and the surface sculpturing has been pointed out by Hall (1931) and Deflandre (1931). The surface sculpturing is widely used as a specific toxonomic character (discussion, Swirenko, 1927; Lefèvre, 1931). However, it has been demonstrated by Lefèvre (1932a, 1932b, 1932c) that when *Euglena spirogyra* is maintained in culture the pellicular ornamentations may decrease and eventually disappear. It seems possible that this tendency for variation with the conditions of culture may account for some of the numerous described varieties of certain species.

Some species of *Euglena* lack a flagellum and move in an amoeboid manner (discussion, Elenkind, 1924a, 1924b). Pascher (1930) considered a colorless amoeba with zoochlorellae and a stigma to be a euglenoid. Valkanov (1934) tentatively assigned another amoeba to the genus *Euglena*.

In four genera (*Trachelomonas*, *Strombomonas*, *Ascoglena*, *Klebsiella*) the cell is sorrounded by a lorica, with an opening at one end from which the flagellum protrudes. In *Trachelomonas*, *Strombomonas*, and *Klebsiella* the lorica is carried about; in *Ascoglena* it is attached to the substrate. The lorica is composed of a firm gelatinous or a rigid material, with no trace of cellulose (Klebs, 1883). The shape of the lorica is used for separating the genera and identifying species, but the exact shape may differ considerably within the species (Deflandre, 1926–27; Gordienko, 1929). When first formed the lorica is very pale in color but later it becomes a dark brown.

In some species (e.g., *Euglena terricola*, Günther, 1928; *Klebsiella*, Pascher, 1931) the posterior portion of the cell secretes a substance (through fine pores) which serves to attach the organism to substrate or lorica.

GULLET, RESERVOIR, AND CONTRACTILE VACUOLE

At the anterior end of the euglenoid cell is the cytostome which opens into a flask-shaped gullet consisting of a narrow tube, the cytopharynx, and an enlarged posterior portion, the reservoir (Fig. 1, *1*). Usually lateral but sometimes posterior (*Astasia linealis*, Pringsheim, 1942) to the reservoir there is a contractile vacuole (two in *Phacus*, Haye, 1930) which empties into the reservoir by fusion and obliteration of the separating walls. This vacuole is replaced by a new vacuole formed by the fusion of several smaller vacuoles. The morphology of the vacuole in a number of euglenoids has been described by Haye (1930) and Chadefaud (1937). Hyman (1937, 1938) has described the formation of the vacuole in *Euglena*, *Phacus*, *Entosiphon*, and *Peranema* (Fig. 2) and has clearly demonstrated that fusion of small vacuoles occurs (cf. Haye, 1930). The formation of the large vacuole by fusion of smaller vesicles is apparently of general occurrence among the Protozoa (King, 1935; Weatherby, 1941). Klebs (1883) found that the maximum rate of contraction in *Euglena deses* and *E. ehrenbergi* (one contraction every 22 seconds) occurred at 32°C. but that the vacuole continued to contract as the temperature was raised, up to 50°C.

According to Gatenby, Singh, and Browne (1938) the reservoir pulsates and is part of the vacuolar system and may at times be closed to the outside. This is an idea expressed by Klebs (1883) and one which has received almost no other recognition since the classical paper by Wager (1899), in which he stated that the reservoir is permanently open to the exterior.

It is this Klebsian concept of the reservoir as a primary vacuole (the real vacuole being called

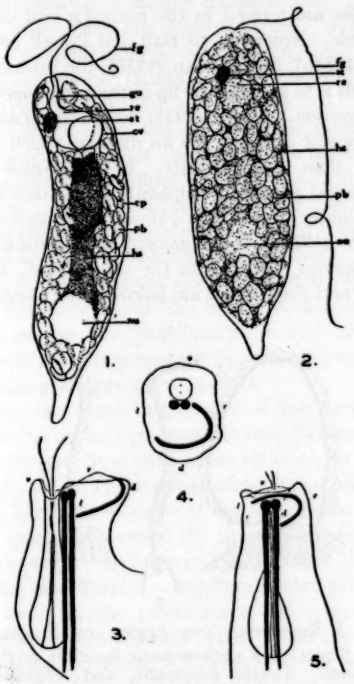


FIG. 1. EUGLENA AND HETERONEMA

1–2. Motile stage of *Euglena rubra* showing structures visible in a living organism. Organism 1 was in shade, and hematochrome is centrally located. Organism 2 was in bright sunlight and hematochrome is located peripherally. Abbreviations: fg, flagellum; gu, gullet (cytopharynx); re, reservoir; st, stigma; cv, contractile vacuole; cp, chloroplast; pb, paramylum body; nu, nucleus; hc, hematochrome. (After Johnson, 1939).

3–5. Heteronema, anterior end, showing gullet and pharyngeal rod apparatus. 3. As seen from left side. Regions of organism indicated as follows: d, dorsal; v, ventral; r, right; l, left. 4. Reconstruction of 3 as would be seen from anterior end. The circle above the pharyngeal rod apparatus is a cross section of the gullet; flagella are indicated by two dots. 5. Reconstruction of 3 as would be seen from the dorsal side. (After Loefer, 1931).

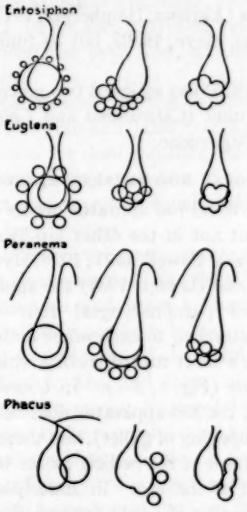


FIG. 2. BEHAVIOR OF CONTRACTILE VACUOLE

In all four species shown the small vacuoles fuse to form a large vacuole which empties by fusion with the reservoir. (After Hyman, 1938).

secondary) that is denoted by the characterization "vacuole system complex" in some of the literature on the euglenoids. In the absence of definite proof it seems best not to revive this concept, but to consider the reservoir to be permanently connected to the outside and not to refer to it as the "primary" vacuole.

In support of the contractile nature of the reservoir, Gatenby, Singh, and Browne (1938) cite the presence of a peri-oral (or perivestibular) ring of osmiophilic material which is supposed to act as a sphincter. This material has been seen by other investigators (*Euglena*, Hamberger, 1911, Günther, 1928; *Phacus*, Haye, 1930), but its function is unknown.

Schiller (1925) has assigned two green flagellates without a gullet (*Chloranima* and *Chlorachne*) to the family Euglenidae.

PHARYNGEAL ROD APPARATUS; INGESTION

The pharyngeal rod appratus occurs in the Peranemidae but not in the other families. In *Peranema* (Hall and Powell, 1927; 1928; Hyman, 1936) and *Heteronema* (Loefer, 1931) the apparatus consists of two parapharyngeal rods which are apparently attached to each other and sometimes anteriorly to a short curved trichite which lies near the cytostome (Fig. 1, *3–5*). In *Urceolus* the anterior end of the rod apparatus does not reach the cytostome (opening of gullet), and there is a separate indentation of the pellicle as far back as the anterior end of the rod. In *Entosiphon* the rod apparatus consists of a tube (often called a siphon) which is as long as the animal and possesses three longitudinal thickenings (Lackey, 1929a). In *Anisonema* the siphon is present but rather inconspicuous. In *Dinema* (Walton, 1915) and *Peranemopsis* (Lackey, 1940a) the rods are similar to those of *Peranema*. According to Brown (1930a), rods are also present in *Petalomonas*, *Tropidoscyphus*, *Marsupiogaster*, and *Scytomonas*. In *Petalomonas* the rods are supposed to be quite short and apparently are difficult to recognize. Rods have not been described for other genera. During division the rod apparatus degenerates, and two new sets are formed in the daughter cells (*Heteronema*, Loefer, 1931; *Peranema*, Brown, 1930a; *Entosiphon*, Lackey, 1929a).

The pharyngeal rods are usually assumed to function in the ingestion of food. In *Peranema*, at least, there is evidence for this assumption. Brown (1930a) stated that in *Peranema* there is a cystostome at the anterior end of the rods and that this cystostome is separate from the opening of the gullet. Rhodes (1926) made a similar statement about *Heteronema*. However, it was definitely demonstrated by Hall (1933b) that in *Peranema* food is ingested through the gullet and that food vacuoles are formed in the posterior end of the reservoir. According to Hall and Powell (1928), Hall (1933b), and Hyman (1936), the function of the rods is to support the lip of the cytostome during ingestion. Ivanic (1935) described pseudopodial feeding of *Peranema* on diatoms which were larger than the flagellate. In *Entosiphon* the pharyngeal apparatus (siphon) is well developed and slightly protrusible. However, according to Lackey (1929a) the organism is saprozoic (cf. Lemmerman, 1913). On the other hand, *Scytomonas* and *Euglenopsis* are holozoic but possess no rods.

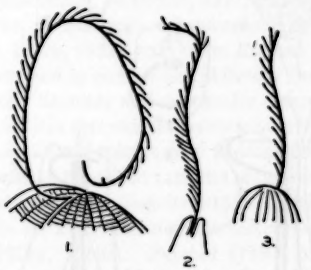


FIG. 3. STRUCTURE AND ACTION OF FLAGELLA

1–3. Structure of stichonematic flagellum of *Phacus pleuronectes*, *Astasia dangeardii*, and *Rhabdomonas incurvum*, respectively. Nigrosin preparations. The finer surface sculpturing of *Phacus* is shown in *1* (*1–3* after Deflandre, 1934c).

FLAGELLA; MOVEMENT

The flagella are inserted into the base of the reservoir and project through the cytopharynx. In all genera carefully investigated (*Distigma*, *Astasia*, *Phacus*, *Euglena*, *Lepocinclis*, *Trachelomonas*, *Urceolus*, *Rhabdomonas*) the flagellum consists of a typical flagellar axoneme surrounded by a sheath to which are attached a number of diagonally arranged mastigonemes (Fischer, 1894; Mainx, 1928; Petersen, 1929; Deflandre, 1934c, 1934d; Vlk, 1938) as shown in Fig. 3, *1–3*. In some euglenoids these are not easily demonstrated (cf. Mainx, 1928; Deflandre, 1934a), but the claims of Dellinger (1909) and of Korschikow (1923) that they are artifacts are now disregarded. These mastigonemes may be observed after mordant staining methods, in dried nigrosin preparations, or in the

living cell with a dark-field microscope. In *Euglena gracilis* the mastigonemes are 3.0 to 3.5 μ long and spaced 1.0 to 1.5 μ apart. On the basis of the distribution of the mastigonemes the type of flagellum possessed by the euglenoids is referred to as "stichonematic" ("flagelle stichonématé," Deflandre, 1934c; "eensidig Fjersvingtraad," Petersen, 1929; "Einseitswendige or Flimmergeissel," Vlk, 1938) or "ciliary" (Kudo, 1939). The function of mastigonemes is apparently unknown.

One outstanding and probably the most characteristic thing about *Peranema* is the behavior of the swimming flagellum which is held in front of the cell. This forward position of the flagellum is responsible for the gliding motion (without cell rotation) which is characteristic of several genera of the Peranemidae and also of the genera *Distigma* and *Sphenomonas* of the family Astasiidae. In some genera one flagellum is trailing and apparently beats only near the tip, thereby producing a similar gliding or creeping effect.

High speed motion pictures of the flagella of *Euglena*, *Phacus*, *Peranema*, *Astasia*, *Rhabdomonas*, and *Distigma* have been taken by Lowndes (1941, 1944). In all species studied he found that the wave like motion begins at the base of the flagellum, progresses toward the tip, and has its main component of force directed away from the tip. In *Euglena viridis* the flagellum pushes obliquely backward thereby producing rotation, gyration, and a forward component, all of which contribute to forward movement. In regard to the position of the flagellum during gyration the figures of Lowndes (1944) are not in agreement with those of Jennings (1906).

When *Peranema* is undergoing its characteristic gliding motion the distal portion of the flagellum is also directed obliquely backward, and the wave is accelerated as it moves from the base. The power for forward movement comes from the rapidly moving wave near the tip. Lowndes is skeptical of the ability of the flagellum of *Peranema* to be the chief mechanism of locomotion under these conditions, but he offers no alternative. When *Peranema* is not gliding, action of the flagellum is the same as in other euglenoids. Lowndes (1944) found that in *Rhabdomonas* there is probably no forward component in the flagellar movement, and he concludes that propulsion is merely the result of rotation and gyration.

Since the power of the stroke in all of the euglenoids studied (and probably in all flagellates) is always in the direction away from the tip, the term "tractellum" is a misnomer when taken to indicate anything except the location of the flagellum. Recent work on flagellar movement is discussed by Barker (1943).

Günther (1928) showed that the rate of locomotion in six species of *Euglena* under uniform conditions varies with the ratio of the flagellar to body length. The rate varies with the species between 0.02 and 0.22 mm/sec. The species of *Trachelomonas* which have flagella many times the body length move much more rapidly than many species of *Euglena* in spite of the drag of the lorica. Several other investigators (Jennings, 1904; Mast and Gover, 1922; Deflandre, 1929; and Lefèvre, 1932c) have described the path and velocity of *Phacus* and *Euglena*.

The type of insertion of the flagellum was proposed by R. P. Hall and Jahn (1929a) as an additional criterion for distinguishing the family Euglenidae from the other families of the order, and this subject has received considerable attention from other investigators.

In all members of the green genera of Euglenidae which have been examined the flagellum is bifurcated at the base and bears a flagellar swelling either at or slightly posterior to the point of bifurcation (Fig. 4, *1–4*). In all of the colorless flagellates examined by Hall and Jahn (1929a, *Astasia*, *Rhabdomonas*, *Peranema*, *Euglenopsis*) the flagellum was found to be non-bifurcated and without a flagellar swelling (Fig. 4, *5–8*). It was suggested that the flagellum of the stigma-bearing species of *Astasia* should be examined and that the organisms should be placed in the family Euglenidae if the flagellum were bifurcated. A bifurcated flagellum with a swelling was found in a stigma-bearing colorless flagellate by S. R. Hall (1931), and he placed this organism in the genus *Euglena*. Another stigma-bearing, colorless organism was described by Jahn and McKibben (1937), and these investigators created the genus *Khawkinea* which differs from *Euglena* only in the absence of chloroplasts.

In vegetative stages of the biflagellate genus *Eutreptia* (Steuer, 1904) and the triflagellate *Euglenamorpha hegneri* (Wenrich, 1924), each flagellum bears a swelling but is not bifurcated. *Euglenamorpha pellucida* is a possible exception which has been discussed by Hall and Jahn (1929a).

Apparently there has never been any serious disagreement with the thesis that all monoflagellate members of the family Euglenidae have a bifurcated flagellum with a flagellar swelling and that

the stigma-bearing colorless flagellates belong in this family. (*Colacium* is in a separate family.)

However, in regard to the flagellum of the colorless flagellates there has been considerable discussion. Brown (1930a) stated (in contradiction to Hall and Powell, 2928, and others) that the flagellum of *Peranema* is bifurcated. Lackey (1933) discovered that the extra ramus described by Brown is really the base of a second flagellum which lies close to the pellicle during ordinary movement. This was corroborated by Hall (1934), who pointed out that Hartmann and Chagas (1910) and Korschikow (1924) had previously described the second flagellum. At present all workers agree that the flagella of *Peranema* are not bifurcated and bear no flagellar swellings. The second flagellum can be caused to separate from the pellicle in the living flagellate by the use of weak gentian violet solutions (Korschikow, 1929, see Hall, 1934; Dunham, 1937), and Chadefaud (1938) has noted a separation with bichromate fixatives.

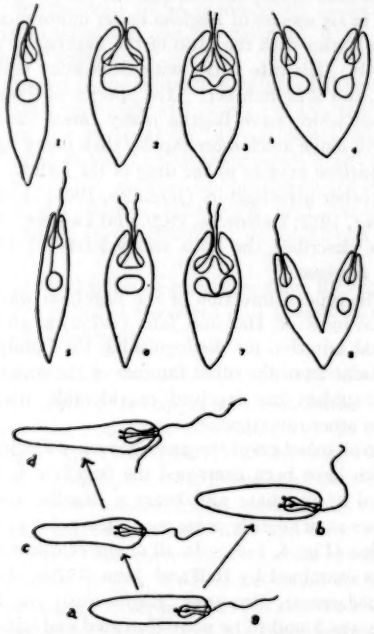


FIG. 4. FLAGELLUM INSERTION OF EUGLENOIDS

Euglena (*1–4*), *Astasia* (*5–8*), and possible phylogeny (*9*). *1*, *Euglena*, vegetative stage showing bifurcated flagellum with flagellar swelling, the rhizoplast extending from one of the blepharoplasts to a granule ("extranuclear centrosome") on the nuclear membrane. *2*, Late prophase or metaphase, with two bifurcated flagella but no flagellar swellings. *3*, Anaphase. *4*, Telophase. *5*, *Astasia*, vegetative stage showing nonbifurcated flagellum without flagellar swelling, and rhizoplast extending to centrosome on nuclear membrane. *6*, Late prophase. *7*, Anaphase. *8*, Telophase. *9*, Phylogenetic development of flagellum insertion according to Lackey (1934a).

a. Hypothetical ancestor with swelling but no bifurcation, a condition later shown by Johnson (1934) to exist in *Colacium*. b. Condition in *Euglena* (*1*, above). c. Condition in *Astasia* according to Lackey, but not as in *5* above. d. Condition in *Peranema* and *Heteronema* (see also Fig. 1, *3–5*, and Fig. 6, *9–15*). (*1–8* after Hall and Jahn, 1929a).

However, in regard to the flagellum of the colorless flagellates there has been considerable discussion. Brown (1930a) stated (in contradiction to Hall and Powell, 2928, and others) that the flagellum of *Peranema* is bifurcated. Lackey (1933) discovered that the extra ramus described by Brown is really the base of a second flagellum which lies close to the pellicle during ordinary movement. This was corroborated by Hall (1934), who pointed out that Hartmann and Chagas (1910) and Korschikow (1924) had previously described the second flagellum. At present all workers agree that the flagella of *Peranema* are not bifurcated and bear no flagellar swellings. The second flagellum can be caused to separate from the pellicle in the living flagellate by the use of weak gentian violet solutions (Korschikow, 1929, see Hall, 1934; Dunham, 1937), and Chadefaud (1938) has noted a separation with bichromate fixatives.

Lackey (1934a) stated, in contradiction to all previous investigators, that the flagellum of *Astasia* is bifurcated. Lackey also pointed out that such a bifurcation permits one to sketch a phylogenetic series in which a hypothetical form with a single flagellum and flagellar swelling but no bifurcation gave rise to two bifurcated types, one with (*Euglena*) and one without (*Astasia*) a swelling (Fig. *4*, *9*). The bifurcated flagellum in the organism without the swelling eventually split throughout its length and gave rise to the biflagellate organisms (*Peranema*, *Heteronema*, *Distigma*) which have neither bifurcation nor flagellar swellings. It now seems apparent that the structure of *Colacium* corresponds to the hypothetical ancestral form (D. F. Johnson, 1934). *Eutreptia* and *Euglenamorpha* could be derived from the hypothetical ancestral form merely by an increase in the number of flagella. Smyth (1943) published a figure of *Astasia harrisii* with flagellar bifurcation and swelling but did not comment on the problem.

In all of the euglenoids studied there is a basal granule, the blepharoplast or mastigosome, at the base of each flagellum or of each ramus of a flagellum. In the monoflagellate Euglenidae one of the blepharoplasts, and in the Astasiidae the sole blepharoplast, is connected to an extranuclear centriole by means of a rhizoplast, as shown in Fig. 4, *1–5* (Hall, 1923; Hall and Jahn, 1929a). In *Peranema* the extranuclear centriole is connected by a rhizoplast to one of the blepharoplasts (Hall, 1934). In *Euglena sanguinea* Haase (1910) reported that the two rami are continued through the cytoplasm to a region posterior to the nucleus, but this report has not been confirmed (Gojdics, 1939).

The mechanics of "metabolic" or "euglenoid movement have not been studied. These movements are most pronounced in *Distigma* but also occur in most non-rigid species.

CHLOROPLASTS, PYRENOIDS, AND PARAMYLUM

The chloroplasts of the euglenoids appear to contain almost pure chlorophyll, but extracts of the whole cell contain carotenoids. Absorption spectra are very similar to those of green plants (Baas-Becking and Ross, 1926; Günther, 1928). The chloroplasts vary greatly in size, shape, and number in different species, and these differences are sometimes used as specific characters, especially in the genus *Euglena* (discussion, Lefèvre, 1931). If *Euglena* is grown in darkness the amount of chlorophyll and the number of chloroplasts is reduced (Zumstein, 1900; Ternetz, 1912; Mainx, 1928), even to the point of extinction (Lwoff and Dusi, 1935). Since chloroplasts always arise from pre-existing chloroplasts, loss of all chloroplasts may result in the beginning of a colorless strain. A list of the colorless strains of normally chlorophyll-bearing species is given by Pringsheim (1937), and the relationship of green and colorless forms is discussed by Pringsheim (1941) and Kirby (1941a).

In some species the chloroplasts possess a pyrenoid which consists of hemispherical projections from either surface. Watch-glass-shaped discs of paramylum may be formed on one or both surfaces of the pyrenoid. Later the paramylum may become detached (Mainx, 1928), and a new sheath is formed. In *E. mucifera* (Mainx, 1926) the pyrenoids are on special short processes on the inner surface of the chloroplast. The pyrenoids are viscous masses of protein, usually arise by division of pre-existing pyrenoids, and when present are apparently responsible for the formation of paramylum. The pyrenoids of the Euglenida are different in structure from those of the Chlorophyceae (Czurda, 1928).

Formation of paramylum is not limited to pyrenoids and in most species it is not formed in contact with the chloroplasts (e.g., *Phacus*, *Lepocinclis*, some species of *Euglena*, and all colorless euglenoids). Where the paramylum bodies are large and have a definite shape and orientation, it is assumed that they are formed in association with definite cytoplasmic structures which are sometimes distinguishable (*E. deses*, *E. viridis*) and have wrongly been termed pyrenoids (Czurda, 1928).

Paramylum (sometimes spelled paramylon) is the typical carbohydrate of the euglenoids and apparently is not found in other orders of flagellates or algae. Paramylum is a higher polysaccharide which does not stain with iodine or zinc-chlor-iodide, is insoluble in boiling water, may be hydrolyzed to glucose, dissolves in concentrated sulfuric acid and potassium hydroxide, sometimes dissolves in formalin, and swells in weak (6 per cent) potassium hydroxide to display a concentric stratification (Molisch, 1923; Czurda, 1928; Deflandre, 1934b; Fritsch, 1935). This concentric stratification may often be seen with a polarizing microscope without the use of hydroxide.

When viewed under crossed Nicol prisms, the paramylum bodies of most species are definitely anisotropic. Most species of *Phacus* and some of *Euglena* show four radial light and dark sections in each paramylum body. In other green species and in *Astasia* the sectors are less pronounced, and in *Rhabdomonas*, *Distigma*, *Petalomonas*, *Anisonema*, and *Entosiphon* the bodies are apparently isotropic. These variations in anisotropy are caused partly by visible differences in size, shape, and position of the bodies but probably also by differences in the ultramicroscopic or molecular structure (Deflandre, 1934b).

Paramylum bodies assume a variety of shapes (flat discs, concavo-convex discs, rods, rings, etc.). The shape and size undoubtedly undergo considerable variation with the state of nutrition of the cell (discussion, Lefèvre, 1931), but the larger characteristically shaped bodies seem to possess a remarkable degree of persistence and are used for the differentiation of species. Development of the more complex shapes has been discussed by Bütschli (1906), Czurda (1928), and Heidt (1937). The ring shaped paramylum bodies of *Euglena sanguinea* are formed first as a cup, and then the center may be dissolved (Heidt, 1937).

STIGMA

The stigma is composed of numerous red granules embedded in a colorless concavo-convex matrix (Fig. 1, *1*, *2*; 5, *1–5*). Wager (1899) described the relationship between the stigma and the flagellar swelling which lies close to the cavity of the stigma, and emphasized the probability that either the swelling or the stigma is a photoreceptor. Engelmann (1882) had previously shown that the anterior end of the organism is most sensitive to light and that the stigma probably is a photoreceptor. The swelling is sometimes referred to as part of the stigma. It is now generally agreed that the stigma is responsible for orientation of euglenoids in a beam of light (Mast, 1911).

Colorless strains of Euglenidae which have a

stigma are phototactic, but those Euglenidae which have no stigma, as well as members of the non-stigma-bearing families Astasiidae and Peranemidae, are not phototactic (Pringsheim, 1937). Members of the colorless families (e.g., *Peranema*) are sensitive to changes in intensity of light but respond by some reaction other than phototaxis (see motor responses, below). Tchakhotine (1936a, 1936b), by means of a ray of intense ultraviolet light focussed on the region of the stigma, rendered *Euglena* incapable of responding to a reduction of intensity of visible light. The present evidence indicates that the flagellar swelling is the organelle sensitive to light, and that the function of the stigma is to act as a shield, which, depending on the orientation, may prevent light from reaching the swelling (Mast, 1911; see motor responses, below).

In two species each of *Euglena* and *Lepocinclis*, Sokoloff (1933, 1935a, 1935b) described an amylaceous body, lying on the side of the gullet opposite the stigma, which is supposed to act as a lens in focussing light on the swelling; apparently this observation has not been confirmed by other investigators. In view of the fact that Mast (1927) showed that light is not focussed in any of the euglenoids he studied, Sokoloff's interpretation should not be accepted without confirmation.

The stigma sometimes divides into two parts during cell division (Grassé, 1926; Günther, 1928; S. R. Hall, 1931; Baker, 1933), and apparently it does not arise *de novo*. The colored granules, however, may disperse during the prophase and then reaggregate during the anaphase (Hall and Jahn 1929b; Gojdics, 1934).

HEMATOCHROME; RED SPECIES

Several species of *Euglena* (*E. ruba*, *E. haematodes*, *E. sanguinea*, *E. rubida*, *E. flava*, *E. orientalis*, and *E. heliorubescens*) and *Colacium sanguinea* (Lackey, 1934b) are sometimes red in color and contain numerous granules (0.5 μ or less in diameter) of the pigment hematochrome; the same or a very similar pigment is sometimes found in smaller quantities in normally green species (e.g., *E. gracilis*, *E. anabaena*, *E. klebsii*, *E. stellata*, *E. pisciformis*, and *Colacium vesiculum*, Hall, 1933c).

The pigment from *E. sanguinea* has been the subject of several chemical and spectroscopic investigations (von Wittich, 1863; Garcin, 1889; Kutscher, 1898; Kylin, 1927) which have demonstrated that it consists of three carotinoids. The principle pigment from *E. heliorubescens* was isolated by Tischer (1936), who found it to be a tetraketo-beta-carotene which he called euglenarhodon; several other carotinoids were also present.

The red species of *Euglena* are most common in pools rich in organic matter, especially if the temperature is above 30°C. Under these conditions they may form a dark red scum over the surface of the water during bright sunshine, and the scum becomes green whenever the sunshine ceases (Kol, 1929; Heidt, 1934; Härdtl, 1935; Johnson, 1939).

If the hematochrome granules are concentrated in the center of the cell (Fig. 1, *1*) the organism appears green because of the more peripheral arrangement of the chloroplasts. However, when the granules are scattered more or less uniformly thoughout the cell (Fig. 1, *2*), the general appearance is red (Heidt, 1934; Härdtl, 1935; Johnson, 1939). It has been found by several workers that dispersion of the granules occurs in response to very bright light, and Johnson and Jahn (1942) found that the blue end of the visible spectrum is much more effective than the red. Heating to temperatures above 30°C. by either immersion or infra-red radiation also causes dispersion.

CYTOPLASMIC INCLUSIONS

Cytoplasmic inclusions have attracted the attention of many investigators (literature on plant-like flagellates cited by Hall, 1936; see also MacLennan, 1941, Weatherby, 1941; and Smyth, 1944). In addition to the chloroplasts, stigma, and associated structures the euglenoids have been considered to have four types of cytoplasmic inclusions: 1) mitochondria or chondriome, 2) vacuome, 3) Golgi material, and 4) mucus bodies. All of these structures can be blackened by osmic acid. In addition, the mitochondria can be stained vitally by Janus green B, the vacuome with neutral red, the Golgi material possibly with neutral red, and the mucus bodies by either neutral red or Janus green, or possibly by neither, depending upon the species under consideration. After osmification the Golgi material is supposedly most resistant to bleaching by oxidizing agents. It has been demonstrated by use of the centrifuge that the specific gravities of the cytoplasmic structures are as follows: paramylum and vacuome > chloroplasts > mitochondria (Patten and Beams, 1936), as shown in Fig. 5, *2*, *3*, *5*.

Mitochondria

Small spherical or bacilliform granules have been identified as mitochondria in *Euglena*

(Causey, 1926; Brown, 1930b; R. P. Hall, 1931; Baker, 1933; Patten and Beams, 1936; Chadefaud, 1937), *Colacium* (Johnson, 1934), *Astasia* (Hall, 1930), *Rhabdomonas* (R. P. Hall, 1931), *Entosiphon* (Lackey, 1929a), and *Peranema* (Hall, 1929; Chadefaud, 1938). These granules are usually scattered in the cytoplasm (Fig. 5, *2*, *3*, *5*); some of those which are arranged peripherally may be identical to the mucus bodies (see below). In *Petalomonas* and *Entosiphon*, Hollande (1940) has described subcuticular structures which stain with mitochondrial stains but which are not identical with the mucus bodies.

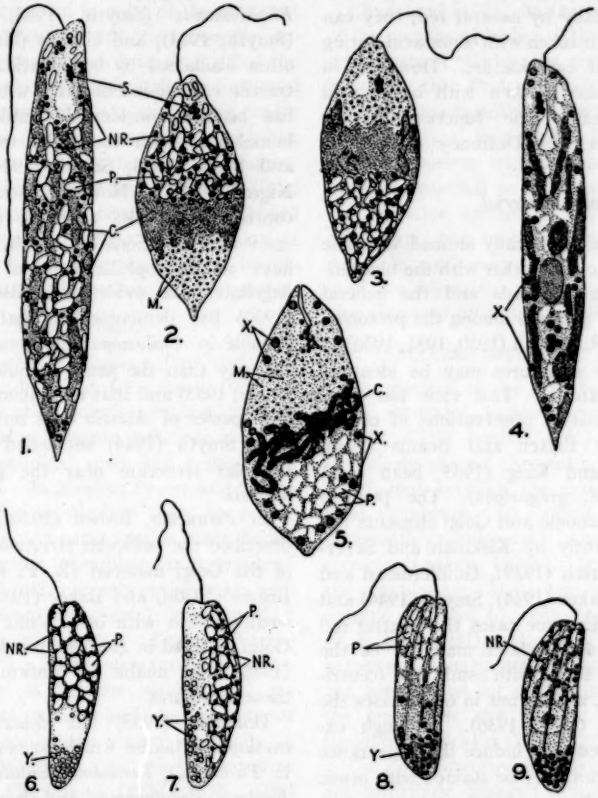


FIG. 5. CYTOPLASMIC INCLUSIONS OF EUGLENA (*1–5*) AND RHABDOMONAS (*6–9*)

1, Living *Euglena*, stained with neutral red, not centrifuged. *2–3*, Same as *1*, but centrifuged. Note that stratification bears no relation to morphological polarity. *4*, Uncentrifuged, Kolachev preparation. *5*, Centrifuged, Kolachev preparation. Note the "peripheral" of "mucus" bodies (X) which are not affected by centrifuging. *6*, Living *Rhabdomonas*, strained with neutral red, not centrifuged. *7*, Same as *6* but centrifuged, lateral stratification. *8*, *Rhabdomonas*, stained vitally with neutral red, then exposed to osmic vapor 48 hrs. *9*, Same as ♀, except exposed for 60 hrs. Drawings *8* and *9* might equally well have been made from osmic preparations not previously stained with neutral red or from Mann Kopsch preparations with or without vital staining. (After Patten and Beams, 1936).

Abbreviations: NR, neutral-red bodies of living organisms and "vacuome" of fixed preparations; C, chloroplasts; M, probable mitochondria; P. paramylum bodies; S, stigma; X, peripheral or mucus bodies; Y, posterior refractile bodies of undetermined nature.

Vacuome

Other small granules scattered throughout the cytoplasm have been identified as the vacuome (Fig. 5, *1–3*, *6–9*) in *Euglena* (R. P. Hall, 1931; Patten and Beams, 1936; Chadefaud, 1936), *Rhabdomonas* (R. P. Hall, 1931; Patten and Beams, 1936), *Peranema* (Hall, 1929; Chadefaud, 1938),

Colacium (Johnson, 1934), *Phacus* (Dangeard, 1928a). These granules can be distinguished from the mitochondria by staining with a mixture of neutral red and Janus green. If these granules are first stained vitally by neutral red, they can then be observed to blacken with osmic acid during direct microscopical examination. However, in most cases they also blacken with osmic acid before vital staining. The function of the vacuome is discussed by Dufrenoy (1940).

Golgi Material

The blackening of the vitally stained vacuome granules by osmic acid, together with the blackening by usual Golgi methods and the general occurrence of these granules among the protozoa, has been taken by R. P. Hall (1930, 1931, 1936) to indicate that these structures may be identical with the Golgi material. This view has been opposed on the basis of observations of centrifuged material by Patten and Beams (1936, *Euglena*), Beams and King (1935, bean root) and Daniels (1938, gregarines). The possible homology of the vacuome and Golgi elements has been reviewed recently by Kirkman and Severinghaus (1938), Hirsch (1939), Guilliermond and Atkinson (1941), Baker (1944), Smyth (1944) and Hibband (1945). In some cases the neutral red staining material of flagellates may not be the same as that which stains with osmic acid (centrifuging experiments, above) but in other cases the two are identical (Hall, 1936). Although exposure to neutral red may induce the appearance of granules which can later be stained with osmic acid (Patten and Beams, 1936), this does not preclude the possibility that some osmiophile material may be present before exposure. It is stated by some cytologists (Cowdry, 1943, and reviews cited above) that Golgi material in multicellular organisms does not stain with neutral red (although it may be associated with neutral red staining material). If this criterion should be applied to unicellular organisms, then the vacuome would be thereby eliminated as a homologue of the Golgi material of higher organisms.

The stigma of *Euglena* is sometimes called the Golgi material (Grassé, 1925, 1926; Duboscq and Grassé, 1933). However, since it is a highly specialized structure ordinarily associated with chlorophyll, it is usually eliminated from consideration as such (Mangenot, 1926; Hall, 1936; Patten and Beams, 1936).

The contractile vacuole or other nearby material in *Euglena* (Sigot, 1931; Gatenby and Singh, 1938), *Rhabdomonas* (Smyth, 1943, 1944), *Astasia* (Smyth, 1944), and ciliates (Nassonov, 1924) is often blackened by osmic acid. Since the contractile vacuole is associated with excretion, there has been a considerable tendency to hold it homologous with the Golgi material (Gatenby and Singh, 1938; Smyth, 1944; cf., Hall and Nigrelli, 1937). However, some ciliates have contractile vacuoles which do not blacken with osmic acid (citations by Smyth, 1944) and others have no osmiophilic material whatsoever. In flagellates, the evidence is also variable. Hall (1930) has demonstrated that the contractile vacuole in *Chilomonas* blackens much less consistently than the small granules (cf. Mast and Doyle, 1935) and that the vacuole of an unidentified species of *Astasia* does not blacken. However, Smyth (1944) succeeded in blackening a vacuolar structure near the gullet in *Astasia harrisii*.

In *Peranema*, Brown (1930a) has apparently described the pellicular striations as a homologue of the Golgi material (R. P. Hall, 1931, 1936). Brown (1930b) and Baker (1933) have identified small spheres with osmiophilic coverings as the Golgi material in *Euglena*, but Patten and Beams (1936) were unable to confirm the existence of these structures.

Hollande (1938) has described endoplasmic osmiophilic bodies which do not take vital stains in *Parastasia*, *Peranema*, *Entosiphon*, *Anisonema*, *Euglena*, *Penatomonas*, and three species of *Heteronema*, and which he believes represent the Golgi material of the euglenoids. He found that the number of such bodies varied from one to twenty-five and was more or less constant for the species.

The only general conclusion that can be made is that the identification of Golgi material in euglenoids is most uncertain. This is the viewpoint taken by Hall (1936) and by Patten and Beams (1936), and at present there seems to be no necessity for revising this statement because of the more recent contributions above (cf., however, Smyth, 1944).

Much of the difficulty of identifying a protistan homologue of the Golgi apparatus of multicellular organisms is that there seems to be no clear definition of this material in terms of staining reactions, morphology, behavior, or function

which is acceptable to most cytologists (cf. Hall, 1930). The only point of universal agreement seems to be the name "Golgi," and most of the difficulty has centered around attempts to attach this name to a structure in spite of the fact that criteria for identification are not generally accepted. In most cases there is no doubt that the described structures exist, although the form and quantity may vary with the conditions under which the organisms were grown and with the techniques used for staining; the point of disagreement is usually that of homology. Similar Golgi problems in metazoa are discussed by Hibbard (1945). Unfortunately, among the confusion of ideas concerning homologies, the possible importance of the structures themselves is often ignored.

Mucus Bodies

In several species of *Euglena* (but definitely not in others, Chadefaud and Provasoli, 1939), in *Peranema*, and in other colorless euglenoids there are small spherical or elongate inclusions arranged in spiral or longitudinal rows just beneath the pellicle (Fig. 5, *4*). In *Euglena* Patten and Beams (1936) were unable to displace them by centrifuging (Fig. 5, *5*). In some species these bodies stain with Janus green ("peripheral mitochondria" of *Peranema*, Hall, 1929); in others they stain with neutral red (*Euglena*, *Anisonema*); in others they are not stainable with either (*Euglena*, Patten and Beams, 1936). These structures are sometimes referred to as "mucus bodies" and apparently contribute to the gelatinous membranous covering of the non-motile stages, especially in *Euglena velata* (Dangeard, 1902) and *E. mucifera* (Mainx, 1926). Chadefaud (1937, 1938, 1939) considers mucus bodies to be homologous with the trichocysts of ciliates and also with the parabasal body of animal flagellates. Furthermore, he states that there is no essential difference between those which stain with Janus green and those which stain with neutral red and cresyl violet. The latter in *Euglena* have been considered to represent the vacuome (Dangeard, 1928a), but it is also possible to stain the vacuome and the mucus bodies in the same organism (Chadefaud, 1937; Dangeard, 1928a; Grassé and Poisson, 1933). Chadefaud (1938) defines the mucus bodies as mitochondrial material which is associated with the locomotor elements and which can elaborate either a glycogen-like material or one which can be stained with vacuome dyes. Patten and Beams (1936) described "peripheral bodies" very similar in shape and position to the above mentioned mucus bodies, but they were able to stain them only with osmic acid and not with vital stains.

Chadefaud (1936), on the basis of his homology of the peripheral bodies of the flagellates with the trichocysts of ciliates, has created a new group of Protista, the Protogastréades, to include the Ciliata, Dinoflagellida, Crytomonadida, Chloromonadida, and Euglenida, all of which are supposed to possess trichocyst homologues. In this group, in contrast to the Gastréades or Metazoa, the digestive system is not differentiated into cell layers, but consists only of the gullet and reservoir, and even this in many cases is not used for ingestion. Trichocyst homologues are also discussed by Reukauf (1940).

NUCLEAR STRUCTURE AND MITOSIS

The nucleus of the euglenoids contains one or more centrally located endosomes (Hall and Powell, 1928; Loefer, 1931) and a number of irregularly shaped chromatin granules which are distributed between the endosome and the nuclear membrane. In *Astasia* and *Distigma* these chromatin granules may constitute a permanent spireme (Lackey, 1934a). In *Khawkinea leucops* the granules are twenty-two in number, and each granule gives rise to a chromosome during mitosis (S. R. Hall, 1931). However, this correspondence between chromatin granules and chromosomes has not been noted for other euglenoids. In all of the euglenoids the nuclear membrane persists throughout division (Figs. 4, 6).

The endosome divides during mitosis but does not contribute material toward the formation of the chromosomes (Fig. 6, *1–8*). In *Distigma*, Lackey (1934a) described a small intranuclear body of unknown function which differed in staining reaction from the endosome. In *Euglena*, Baker (1926) assumed that the endosome gives rise to a bud which gives rise to the centrosome and blepharoplasts, and Ratcliffe (1927) made similar assumptions for another intranuclear body. These proposals have been criticized by Hall and Powell (1928).

Mitosis in a variety of euglenoids has been described by numerous investigators (early literature cited by Hall, 1923; *Rhabdomonas:* Hall, 1923; *Euglena:* Baker, 1926; Ratcliffe, 1927; S. R. Hall, 1931; Gojdics, 1934; Krichenbauer, 1937; *Peranema:* Hall and Powell, 1928; Brown, 1930a; Lackey, 1933; Hall, 1934; *Colacium:*

Johnson, 1934; *Heteronema:* Loefer, 1931; *Entosiphon:* Lackey, 1929a; *Distigma:* Lackey, 1934; *Astasia:* Bělař, 1926, Lackey, 1934a). Early observations were reviewed by Bělař (1926), and the significance of euglenoid mitosis was discussed by Drezepolski (1929). Amitosis was described for *Euglena* by Jírovec (1926), but this was apparently a misinterpretation.

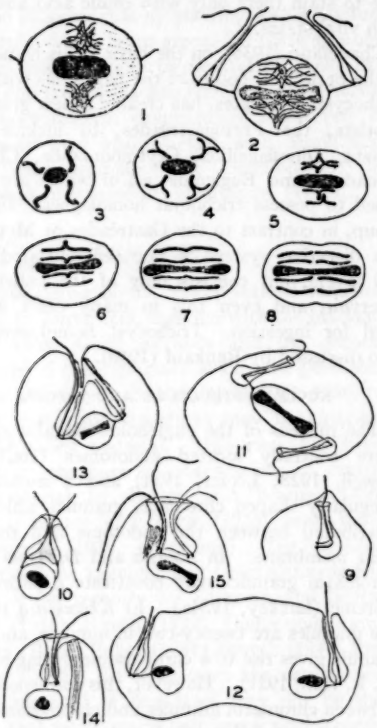


FIG. 6. MITOSIS IN EUGLENA, PERANEMA, AND ENTOSIPHON

1–8, Nuclear phenomena in *Euglena*. *1*, Equatorial "plate" stage, optical section, somewhat diagrammatic. *2*, Slightly later stage, unfolding of V's is pronounced. *3–8*, Behavior of chromosomes, hypothetical case with four chromosomes, showing longitudinal splitting.

9–13, *Peranema*, pharyngeal rods not shown. *9*, Stage figured by Hall and Powell (1928) and interpreted as outgrowth of a new flagellum in binary fission, possibly a separation phase earlier than *10*. *10*, Prophase showing one large flagellum on each side of widened gullet. *11*, *13*, Early anaphases with one large flagellum and one short outgrowth in each daughter gullet. *12*, Telophase, showing one large and one small flagellum in each gullet.

14–15, *Entosiphon sulcatum*. *14*, Late "prophase," showing retention of old flagella and outgrowth of two new ones. *15*, Later stage, flagella grown beyond cytostome. (*1–8*, After Hall, 1937a; *9–12*, after Hall, 1934; *13*, after Lackey, 1933; *14–15*, after Lackey, 1929a).

During division of organisms with one flagellum the blepharoplast divides, and one part passes to each daughter cell. The flagellum may remain attached to one blepharoplast, and a new flagellum then grows out from the other (e.g., *Astasia*, *Lackey*, 1934a). In *E. gracilis*, Krichenbaur (1937) has described the separation of the rami of the flagellum so that one ramus goes to each daughter. In organisms with two flagella both flagella may go to one daughter (*Entosiphon*, Lackey, 1929a; Fig. 6, *14–15*) or each daughter may receive one of the old flagella (*Heteronema*, Loefer, 1931; *Peranema*, Hall, 1934; Fig. 6, *9–13*). In the Euglenidae the flagellar swelling disappears during the prophase and later reappears (Fig. 4, *1–4*).

During the prophase stages the chromatin granules (if they have not already done so) become recognizable as definite chromosomes and apparently become divided longitudinally. This longitudinal splitting of the chromosomes has been described as occurring in the prophase (Baker, 1926, *Euglena agilis*) metaphase (Ratcliffe, 1927, *E. spirogyra*), and telophase (Tschenzoff, 1916, *E. viridis*) stages.

During the metaphase the endosome is elongated, and the chromosomes form what superficially appears to be an equatorial plate (Fig. 6, *1*). However, upon closer examination this "plate" is seen to be made up of a number of V and Y-shaped chromosomes, and each double chromosome has one arm toward each of the poles. This has been observed for *Peranema*, *Astasia*, *Distigma*, *Rhabdomonas*, *Heteronema*, *Colacium*, and *Euglena* (literature cited by Lackey, 1934a; Hall, 1937a). These V's and Y's unfold so that one half goes to each pole. The division of the chromosomes is definitely longitudinal (cf. S. R. Hall, 1931; Gojdics, 1934), and the chromosomes of the euglenoids during the metaphase differ from those in typical metazoan mitosis only in that they do not become greatly shortened and are not arranged in one plane.

The effect of chronic arsenic poisoning on nuclear structure is discussed by Rybinsky and Zrykina (1935).

LIFE HISTORY; REPRODUCTION, CYSTS, AND PALMELLA STAGES

The life history of a euglenoid may consist of flagellated and encysted stages, with palmella

stages in the Euglenidae and Colaciidae, and plasmodial stages in the Colaciidae only. Reproduction is usually by longitudinal binary fission of the flagellated stage. Transverse division has been reported only by Tannreuther (1923). In some species of *Euglena* division may occur in thin-walled cysts or in palmella stages. In *Trachelomonas* division usually occurs in the old test, and one of the daughters secretes a new one (Klebs, 1883; Gimesi, 1930). However, the flagellate may leave the test before division, and then each daughter secretes a new test (Wilson, 1928). *Colacium* differs from all other genera in that division apparently does not occur in the flagellated stage (see below).

Encysted stages have been described for several genera, including *Euglena* (many investigators, especially Mainx, 1928, and Günther, 1928), *Phacus* (Smith, 1933), *Trachelomonas* (Smith, 1933), *Eutreptia* (Steuer, 1904), *Rhabdomonas* (Lemmerman, 1913) and *Distigma* (Lackey, 1934a), and probably exist for others.

The cyst wall in *Euglena* is composed of an unidentified carbohydrate (Bütschli, 1906). Cysts are usually spherical but may be flask-shaped (*E. orientalis*, *E. tuba*) or pentagonal (*Distigma*).

In the life history of some species of *Euglena*, there may be formed as many as three types of cysts and a palmella stage (Mainx, 1928; Günther, 1928). The types of cysts are:

1) Protective cysts. Single celled, with heavy, sometimes stratified wall, usually cemented to a palmella-like membrane, ornamented in *E. chlamydophora*. Seldom occur in culture, except sporadically in very old ones. Occur in *E. deses* at 0-4°C.

2) Reproductive or division cysts. Uni- to multicellular with thin, elastic, and permeable membrane which increases in diameter as the cells divide. Not present in most species. In *E. gracilis* and *E. viridis* may contain up to 32 or even 64 cells. Cells non-flagellated.

3) Temporary, resting, or transitory cysts. Wall thick but not completely closed, cell usually flagellated and free to move about in cavity. Formed in response to strong sunlight. Occur in *E. gracilis*, in the mud-dwelling *E. terricola*, *E. geniculata*, *E. sanguinea*, and perhaps in *E viridis* and *E. piscitormis*.

In some species there are also thin-walled cysts in which reproduction is not known to occur (*E. tuba*).

The palmella stage consists of non-flagellated organisms embedded in a gelatinous matrix which is often found attached to the wall of old laboratory cultures. Division occurs in the palmella, and the organisms may become flagellated and leave the matrix. The palmella stage is one of the two characteristic stages of *Colacium*, is less common among the genus *Euglena*, and does not occur in the colorless families. It is the most common stage of the genus *Euglenocapsa* (Steinecke, 1932). Palmella stages of euglenoids can be distinguished from those of other flagellates by the typical euglenoid stigma and the presence of paramylum.

According to Mainx (1928), formation of palmella stages may be determined by the following: 1) Content and concentration of medium. They occur on agar in many species. 2) Extremes of temperature, especially when change is sudden. 3) Sudden change of pH. 4) Sudden changes from light to darkness, or vice versa, depending on amount of reserve material in cell.

SEXUAL PHENOMENA

There are unconfirmed reports of gametic union for several euglenoids. The most often cited example is that of *Copromonas* (Dobell, 1908), but the details of copulation and even the identification of this organism are in doubt (Gatenby and Singh, 1938; Gatenby and Smyth, 1940; Chadefaud, 1938). The structure of the nucleus and the type of flagellar insertion would indicate that the organism described by Dobell is not a euglenoid. Abnormal divisions of *Khawkinea halli* which resulted in binucleate individuals and which could easily be mistaken for copulation have been described by Jahn and McKibben (1937), who emphasized this as a possible source of confusion. Binucleate individuals of *E. deses* have been reported by Gojdics (1934) and a trinucleate *Khawkinea ocellata* by Mainx (1928). Haase (1910) described what she supposed were sexual stages in *Euglena sanguinea*, but it has been suggested that these were parasites (Mainx, 1928), and no sexual stages have been reported by more recent investigators (e.g., Gojdics, 1939) who have studied the same species. Biecheler (1937) observed (a dozen times) the fusion of pairs of cells of an unidentified species of *Euglena* from brackish water. He was unable to repeat the observation with *Euglena* from other sources. Krichenbauer (1937) has described bi- and quadrinucleate stages of *Phacus* which he considered to be evidence of reduction and autogamy. However, Pochmann (1942) has suggested that these

may be the result of abnormal culture conditions (see also, Mainx, 1928). Lackey (1929b) made a very careful search for endomixis or conjugation in *Entosiphon* and *Peranema* and was unable to find evidence that they exist. At present the existence of sexual phenomena in the euglenoids remains unconfirmed. The question of whether the euglenoid cell is normally haploid or diploid is discussed by Chadefaud (1940), but in the absence of proof of the existence of sexual phenomena this question seems somewhat far-fetched.

NUTRITION

During the past fifteen years many phototrophic and saprozoic euglenoids have been grown in bacteria-free culture, and measurements have been made of the effect on growth of various fatty acids, alcohols, amino acids, peptones, proteins, carbohydrates, minerals, and vitamins. Numerous studies of this type have been performed at Prague by E. G. Pringsheim and F. Mainx, at the Pasteur Institute by A. Lwoff, H. Dusi, and L. Provasali, and at New York University and other American laboratories by R. P. Hall, T. L. Jahn, J. B. Loefer, A. M. Elliott, and H. W. Schoenborn. The nutrition of the euglenoids has been reviewed by von Brand (1935), Hall (1939, 1941a), and Doyle (1943), whose papers should be consulted for the literature. Methods of isolation consist of successive washing in sterile medium, of choosing colonies from an agar streak, of allowing the flagellates to migrate away from the bacteria, and the killing of bacteria found with encysted stages by chemical agents (literature cited by Mainx, 1928; Hall, 1937c; Kidder, 1941).

The only chlorophyll-bearing genus which has been intensively studied from the viewpoint of nutrition is *Euglena*. All members of this genus are apparently both phototrophic and heterotrophic, i.e., they can utilize either carbon dioxide or dissolved organic compounds as a carbon source. Contrary to the statement of Tannreuther (1923) and to those found in several elementary and semi-popular books, *Euglena* seldom, if ever, ingests particulate food (Hall, 1933c, Baker, 1933). The statements of Tannreuther are commonly regarded as the result of a misinterpretation.

Phototrophic Nutrition

Phototrophic organisms can utilize carbon dioxide as a carbon source in the presence of light, and on the basis of the type of nitrogen compounds needed may be classified into three groups; photoautotrophic, photomesotrophic, and photometatrophic.

Photoautotrophic organisms are able to utilize ammonium and nitrate compounds as nitrogen sources. Examples of facultative photoautotrophs are *E. anabaena*, *E. gracilis* (Schoenborn, 1942), *E. klebsii*, *E. stellata*, *E. terricola*, *E. geniculata*, *E. viridis;* no obligatory photoautotroph is known.

Media which have been used under conditions which permit only photoautotrophic nutrition (Hall and co-workers) contain a number of chemical elements in either appreciable quantities or traces. It should be possible by means of successive eliminations to determine exactly which elements are necessary. It has been determined that the calcium requirement of *E. stellata* is apparently higher than that of other euglenoids, and that Mn accelerates the growth of *E. anabaena*.

Other species of *Euglena* require certain amino acids as a nitrogen source (photomesotrophs); an example of an obligatory photomesotroph is *E. deses*, an organism which apparently can not grow in inorganic media. Several species are known to be facultative photomesotrophs (i.e., are also photoautotrophs): *E. anabaena*, *E. gracilis*, *E. klebsii*, and *E. stellata*. One interesting feature of photomesotrophic nutrition is that a particular amino acid may support growth of one species but not of another. For example, phenylalanine was satisfactory for *E. anabaena*, *E. gracilis*, and *E. stellata*, but not for *E. deses* and *E. klebsii*, while serine was adequate for all of the above except *E. anabaena*. Comparable differences are known for other amino acids. Growth of photomesotrophic species is accelerated by the addition of organic carbon sources (e.g., sodium acetate) to a medium containing one or more amino acids.

Photometatrophic nutrition (utilization of peptones or proteins as nitrogen source) is possible for all green flagellates that have been grown in pure culture. It is possible that *E. pisciformis* may be an obligatory photometatroph, but there is some evidence to the contrary. Certain species are known to produce proteolytic enzymes.

Acceleration of growth of *Euglena* under photometatrophic conditions can be obtained by the use of media containing salts of certain organic acids, various carbohydrates, and alcohols. Salts of acetic and butyric acids are particularly effective.

Heterotrophic nutrition

Heterotrophic organisms do not contain chlorophyll and must depend ubon organic compounds for a source of carbon. *Euglena* in the dark, however, may be considered a facultative heterotroph. On the basis of the nitrogen source needed, three types can be distinguished: heteroautotrophic, heteromesotrophic, and heterometatrophic.

Heteroautotrophic nutrition (utilization of inorganic nitrogen compounds) is known to occur in *Astasia* and in *Euglena gracilis* in darkness when grown in a medium of ammonium nitrate and acetate. The only difference between the minimum nutritional requirements of *Astasia* and the photoautotrophic species of *Euglena* is that *Astasia* needs a simple organic source of carbon.

Heteromesotrophic nutrition (use of amino acids) has not been definitely proven for any euglenoid but is known for members of other orders.

Heterometatrophic nutrition (use of peptones plus possible addition of other organic carbon sources) is known to occur in all of the colorless euglenoids which have been investigated and in some chlorophyll-bearing species in darkness.

Growth of most euglenoids is accelerated by certain lower organic acids and in some species by lower alcohols. The general occurrence of an acceleration of growth and increase in carbohydrate reserves in the presence of acetate is considered by Lwoff and Dusi (1936) to indicate that acetic acid is a normal step in the synthesis of carbohydrate from carbon dioxide. The importance of acetate metabolism is also discussed by Pringsheim (1935). Whenever the utilization of an organic acid is studied it is necessary to control the pH so that the effect of the organic ion may be separated from that of the undissociated molecule (Jahn, 1934), especially since these effects may be opposed. Evidence of such an effect was obtained by von Dach (1940) for *Astasia klebsii.*

The question of whether or not euglenoids require specific chemical growth factors has been reviewed by Hall (1943). It has been demonstrated that the photoautotrophic species of *Euglena* (listed above) do not require thiazole, pyrimidine, or thiamin. These substances are also not necessary for the growth of *Astasia* sp. and of *Euglena gracilis* in darkness when in acetate mineral medium, nor for *E. anabaena* in the light in asparagine or amino acid-mineral media. However, in the latter media there is some evidence that thiazole and pyrimidine, but not thiamin, are necessary for growth of *E. pisciformis*, and and that pyrimidine but not thiazole or thiamine for growth of *E. gracilis* in darkness. Since these positive results apparently require confirmation (Hall, 1943), it seems as if there is no conclusive evidence that euglenoids need any of these growth factors.

Elliott (1937, 1938) demonstrated that growth of *Euglena gracilis* in light but not in darkness is accelerated by the addition of auxin to the culture medium, especially if the pH is about 5.6. Growth of *Khawkinea halli* is not accelerated at any pH by auxin.

In addition to the mineral requirements noted above, it has been claimed by Pringsheim (1926) that calcium is not necessary for the growth of *Euglena gracillis.* However, the conclusion has been questioned by Mast and Pace (1939) who found calcium present in magnesium salts such as those used by Pringsheim. Mainx (1928) found that iron oxide produces a definite acceleration of the growth of *E. deses* and *E. viridis*, a slight acceleration of *E. mucifera* and *E. velata*, but no acceleration of *E. gracilis* and *E. intermedia.* The oligodynamic effect of metals has been studied by Jírovec (1934b).

The chemical changes produced in culture media have been studied by Hall (1937b). Gelatin is liquefied by *Euglena gracilis*, slightly liquefied by *E. klebsii*, but not by several other species. No species was found which can produce indol. Reduction of nitrate to nitrite in the absence of sugar is performed by *E. anabaena*, *E. deses*, *E. klebsii*, *E. pisciformis*, *E. viridis*, and *Colacium vesiculum* but not by *E. stellata.* In the presence of dextrose, reduction is performed by all of the above except *E. deses* and *E. stellata.*

Holozoic nutrition

Holozoic species have not been obtained in bacteria-free culture, and very little is known about their nhtritional requirements.

RESPIRATION

The only thorough study of respiration of a euglenoid was made by von Dach (1942), who used bacteria-free culthres of *Astasia klebsii* He found that respiration is increased to a level (compared to that in inorganic media) of 783

per cent by the addition of acetate, 489 per cent by ethanol, 328 per cent by propionate, 195 per cent by butyrate, 168 per cent by hexosediphosphate, and 158 per cent by formate, but is not changed by the addition of a variety of other organic acids or sugars. The respiratory quotient in both organic and inorganic media is approximately 1.0. Von Dach determined spectroscopically that cytochromes a, b, and c are present. In inorganic media, respiration is reduced by cyanide but accelerated by azide. However, in the presence of acetate respiration is reduced by both cyanide and azide. Therefore, two respiratory mechanisms must be present. The only other detection of cytochrome in a euglenoid is that of Lwoff (1933), who found the cytochrome c band in *E. gracilis*. The methods, theories, and interpretations involved in such measurements have been reviewed by Jahn (1941).

MOTOR RESPONSES

All the green genera and the stigma-bearing colorless forms are phototactic; the non-stigma-bearing forms may respond to light by other reactions but are never phototactic. Our present knowledge of the motor responses of *Euglena* and of *Peranema* to light is largely the result of investigations which have been carried on for many years at Johns Hopkin's University by H. S. Jennings and S. O. Mast and their associates and students, M. Gover, B. Hawk, L. B. Shettles, and C. Hassett. This subject has been reviewed by Jennings (1906), Mast (1911, 1936, 1941) and Warden, Jenkins, and Warner (1940), and these publications should be consulted for literature prior to 1941.

Euglena swims in a spiral path with the flagellum directed obliquely backward near the side opposite the stigma, i.e., the ventral side (Fig. 5, *1*), and the cell rotates so that the stigma maintains a constant position in relation to the main axis of progression. In photopositive organisms, if the intensity is rapidly decreased the organism stops suddenly, turns in a direction toward the surface on which the stigma occurs, and then proceeds in a different direction.

Euglena may be either photopositive or photonegative. If it is photopositive and is oriented, the position of the stigma in relation to the path remains constant and light falls continously on the flagellar swelling. If the direction of the light is changed, the stigma comes between the light and the swelling and causes a sudden decrease in illumination of the swelling, and this produces a shock reaction which ends in a corrective change in the direction of movement. Orientation, then, is the result of rotation of the organism on its longitudinal axis and the ability of the flagellar swelling to produce shock reactions upon sudden changes of intensity. If light from two sources strikes the animal, the direction of locomotion is determined by the relative intensities. *Euglena* is normally photopositive in weak and photonegative in strong light, but reversal of the photopositive response may occur if the intensity is held constant and the temperature lowered by 10 to 15°C. These changes are closely correlated with the state of adaptation.

Several investigators (Mast 1917, 1927, 1941; Dangeard, 1928b) have studied the effectiveness of various wavelengths in the response of *Euglena* to light. For five species of *Euglena*, for *Phacus*, and for *Trachelomonas* these are 410 to 540 mμ, with a peak of effectiveness at about 485 mμ; for *Peranema* the most effective wavelengths are 302 mμ and 505 mμ. Tchakhotine (1936a,b) has demonstrated that the entire surface, and especially the anterior end, of *Euglena* is sensitive to stimulation by intense ultraviolet light.

Peranema responds to a rapid increase in intensity by a 90° change in direction. A rapid decrease or a slow increase has no effect. The whole organism is sensitive to light, the flagellum being most sensitive and the posterior end least sensitive. As measured by the reaction time, the dark adaptation curve of *Peranema* is very interesting. If *Peranema* is transferred from light to darkness, upon exposure to 2000 meter candles the reaction time decreases from about 31 seconds after 15 minutes in darkness to 4.5 seconds after an hour, and then increases to 63 seconds after six hours. During light adaptation the reaction time decreases to a minimum of about 15 seconds in 30 minutes, and then increases to a constant level of about 20 to 25 seconds. The phenomena of adaptation are apparently complex, and no adequate theory has been proposed which will explain the results. Shortess (1942) found that constant light of moderate intensity has no effect on the rate of locomotion, but that at high intensity the rate is increased below 14°C. and is decreased above 14°C. Hassett (1944) demonstrated that the sensitivity of *Peranema* to light, as measured by the reaction times, is greatly increased by the presence of fluorescent dyes (eosin,

rose bengal, neutral red). This photodynamic effect is not in accord with the reciprocity law.

Members of the Euglenidae and Astasiidae are characteristically free swimming. However, some few species which have short flagella or none (e.g., *E. deses*, *E. x.*, see Mast, 1911) sometimes or always "glide" on the substratum. Members of the family Peranemidae are usually in contact with a surface and move by a "gliding" motion. This may be linked with the holozoic method of nutrition in the latter. If the flagellum of *Peranema* strikes a sand grain, the response is a typical shock reaction, with a 90° change in the direction of locomotion.

Bancroft (1913) found that *Euglena* is either positively or negatively galvanotropic and that the ability of the animal to respond depends upon the acidity of the medium. Schröder (1927) reported anodal galvanotropism which is greater in a basic medium. Galvanotropism, however, is a phase of euglenoid physiology which has not yet been adequately explored.

All of the Euglenidae, most of the Astasiidae, but not most of the Peranemidae are negatively geotropic and tend to aggregate at the surface of cultures, especially toward the light. *Euglena* also reacts against centrifugal force when the magnitude of the force is between one half and eight and a half times gravity.

De Wildeman (1894) found that *Euglena* is thermotactic, but that high temperature is such a weak stimulus for negative thermotaxis that the organisms can be attracted by light to lethal temperatures (de Wildeman, 1928).

PARASITES

Parasites of the euglenoids consist of one species of bacterium and at least five genera of Phycomycetes, all of which are usually fatal to the host. Literature citations are given by Kirby (1941b) and Sparrow (1943). Sparrow's book contains clear diagnoses of genera and should do much toward relieving confusion in this field among protozoologists.

The sole bacterial parasite, *Caryococcus hypertrophicus*, was described by Dangeard in 1902 in the nucleus of *Euglena deses*, and apparently has not again been reported.

The most common Phycomycetes are the often confused genera *Sphaerita* and *Pseudosphaerita*. These organisms apparently have been seen in *Euglena*, *Phacus*, *Peranema*, *Trachelomonas*, *Tropidoscyphus*, and *Anisonema*. The parasites consist of amoeboid organisms which grow in the cytoplasm and later undergo multiple fission (*Sphaerita*) or repeated binary fission (*Pseudosphaerita*) to form many spores. The spores are often described as being non-flagellated, but according to Sparrow are monoflagellate in *Sphaerita* and biflagellate in *Pseudosphaerita*. The spores are released through an opening in the host cell, and were formerly thought to be sexual stages of the host. Infection of a new host occurs either by attachment of the flagellate to the pellicle or possibly by entrance through the gullet. Sexual phenomena have been reported. A list of described species is given by Jahn (1933b).

The genus *Olpidium* occurs in *Euglena* and differs from *Sphaerita* in that the spores are retained until fully formed in a sac which is partly on the outside of the host.

The genus *Polyphagus*, which attacks *Euglena*, develops outside the host body, into which it projects a rhizoid. A single *Polyphagus*, by means of branched rhizoids, may attack as many as fifty flagellates, from which it extracts cytoplasm. Numerous flagellated zoospores are formed, copulation occurs, and the zygote becomes a resistant spore. *Polyphagus* may be parasitized by *Pleolpidium*.

The genus *Scherffeliomyces* is epibiotic on *Euglena*.

IMMUNITY REACTIONS

A number of investigators have studied the serological reactions produced in vertebrates by the injection of euglenoids or of euglenoid extracts. Much of the earlier work is invalid because the euglenoids were not free of bacteria (literature, Steinecke, 1925). However, the existence of definite antibodies has been demonstrated by Mary Elmore Sauer (citations below) and Tanzer (1941). The injected vertebrate produces a cytotoxic antibody which causes loss of flagellum and death when the immune serum is added to a fresh culture (Elmore, 1928a). An anaphylactic reaction can also be demonstrated with guinea pigs (Elmore, 1928b). The antibody is thermostable, is species specific (antibody for *Euglena gracilis* is not toxic for *E. proxima* or *E. polymorpha*), does not require complement, exhibits certain absorptive phenomena, and may produce passive sensitization. In short, it behaves as a true antibody (Sauer, 1935a). It has also been demonstrated that the green and colorless (grown in darkness) strains of *E. gracilis* are serologically

distinct (Elmore, 1928b) and that there are also two green strains which differ n their reactions (Sauer, 1935b). Tanzer (1941) obtained cytotoxic antisera for *Astasia* sp., *Khawkinea halli*, *K. ocellata*, *Euglena gracilis*, and *E. viridis*. The serum for *K. halli* produced not only loss of the flagellum but the formation of a gelatinous exudate. Tanzer also showed that *K. halli* is serologically distinct from *K. ocellata*, and that these two species are more closely related to *Euglena* than to *Astasia*.

POPULATION STUDIES

Euglena has been used for population studies by several investigators. Jahn (1930) showed that growth tended to follow the autocatalytic curve and that this precluded the action of an "autocatalyst." Jahn (1929) and Hall and Schoenborn (1939) found an inverse relationship between growth rate and initial population density. Sweet (1939) showed that the relationship between growth rate and initial density may vary with environmental conditions and sometimes may be direct rather than inverse. Population problems of the euglenoids are discussed by Hall (1941b).

TAXONOMY OF FAMILIES

The order Euglenida is usually considered to consist of three families (Euglenidae; Astasiidae; and Peranemidae, Anisonemidae, or Heteronemidae) or sometimes four when a separate family is created for the genus *Colacium* (Smith, 1933). Doflein and Reichenow (1928-1929) combined the families Euglenidae and Astasiidae on the basis of the type of symmetry, but his combination has been severely criticized (Hall and Jahn, 1929a) and is not adopted by recent investigators. Calkins (1933), in a bold but vain attempt to separate plants from animals, reclassified all of the colorless euglenoids among the animal flagellates (Protomonadida) solely on the basis of absence of chlorophyll. This scheme also has been criticized (Hall, 1934; Jahn and McKibben, 1937; Hyman, 1938) and generally discarded.

Euglenidae

The family Euglenidae consists of the chlorophyll-bearing species and those which are immediately derived from them. All members of the family possess a flagellar swelling and all of the monoflagellate genera have a bifurcated flagellum. Most of the colorless species possess a stigma and differ from their chlorophyll-bearing counterparts only in the absence of chlorophyll, which was apparently lost during one or more unequal cell divisions (*Khawkinea linealis*, *K. ocellata*, *K. quartana*, *K. halli*, *Hyalophacus ocellata*, *Trachelomonas reticulata*, *T. volvocina hyalina*, *Euglena sanguinea hyalina*, *E. viridis hyalina*). In a few colorless species the stigma has also been lost (*Euglena acus hyalina*, *Phacus pleuronectes hyalina*; literature cited by Pringsheim, 1937). The organisms commonly assigned to this family are the green genera *Euglena*, *Phacus*, *Lepocinclis*, *Trachelomonas*, *Strombomonas*, *Euglenocapsa*, *Ascoglena*, *Klebsiella*, *Eutreptia*, *Eutreptiella* (syn. *Gymnastica*), and *Euglenamorpha*, and the colorless genera *Khawkinea* and *Hegneria*. The name *Lepocinclis* is preferable to *Crumenula* in spite of the priority of the latter (Deflandre, 1932).

Colaciidae

The family Colaciidae (Colaciaceae) was created by Smith (1933) to contain the genus *Colacium*. The life history of *Colacium* as determined by Johnson (1934) and others shows that the separation is well warranted. The organism apparently spends most of its life cycle in nonflagellated stages, either as a palmella or as a stalked dendroid colony. In the palmella stage both binary fission and nuclear division without cytoplasmic division may occur, so that either mononucleated or plasmodial palmella stages may result. The plasmodial stages give rise to mononucleate flagellates by budding. Flagellate stages may also arise directly from a dividing mononucleate palmella cell. The flagellate has a stigma, a gullet, and a single flagellum without bifurcation but with a flagellar swelling (Fig. 4, 9a). Division does not occur in the flagellated stage, and the flagellate may develop into either a palmella or a stalked colony. In developing into the stalked form the anterior end of the flagellate becomes attached, the flagellum is lost, and a gelatinous covering is secreted. The stalk results from a more profuse secretion at the anterior end. The dichotomous branching of the dendroid colony results from longitudidal division and the secretion of more stalk by each daughter cell.

Astasiidae and Peranemidae

The colorless euglenoids (other than those listed above) are ordinarily divided into two families: 1) the Astasiidae and 2) the Peranemidae, Heterodemidae or Anisonemidae. Various criteria for separating the families are used by different in-

vestigators, and none of them is completely satisfactory. Some possible criteria are: type of locomotion, the Astasiidae being considered as free swimming and rotating and the Peranemidae as gliding; nutrition, Astasiidae being saprozoic, Peranemidae holozoic; pharyngeal rods, absent in Astasiidae, present in Peranemidae; number of flagella, one in Astasiidae, two in Peranemidae; type of symmetry, radial in Astasiidae, bilateral in Peranemidae; the type of flagellum insertion, discussed above. Certain organisms have been placed in either family, depending upon the particular criterion chosen.

If we accept *Peranema* as the type genus for the second family we then have a type genus which is holozic, normally moves by gliding, and possesses two flagella and a pharyngeal rod apparatus. This organism is the most common and best known of the family Peranemidae and is easily distinguished from all genera of the Astasiidae. For these and also for historical reasons (Hall, 1934; cf. Lackey, 1934b) it seems to be the best choice for a type genus. The only real difficulty is in choosing a suitable criterion for separating the Peranemidae from the Astasiidae in such a way that confusion in identification of genera will be at a minimum and that phylogenetic relationships will seem most probable.

The ability to glide or creep by means of limited flagellar movement is equally characteristic of most other genera of the Peranemidae as it is of *Peranema* and could possibly be used as a criterion, thereby placing *Distigma* and *Sphenomonas* in the Peranemidae. Although all of the Peranemidae are apparently capable of gliding movement, some of them may rotate as they swim (even *Peranema*).

There are several monoflagellate genera that are assigned to the Astasiidae because they are monoflagellate or to the Peranemidae for some other reason (*Petalomonas*, *Urceolus*, *Scytomonas*, and *Clautriavia*, *Triangulomonas*, *Peranemopsis*). Inasmuch as the second flagellum in the large and very common *Peranema* remained undetected for so many years it seems quite possible that some of these may prove to be biflagellate. However, even if we knew definitely which genera were biflagellate it would not seem practical to separate the families on the basis of the number of flagella when in some genera one flagellum is ordinarily not detected even by careful observation. The use of *Heteronema* (Calkins, 1926; Lackey, 1934a) or *Anisonema* (Kudo, 1939) as the type genus does not help the situation.

The type of flagellum insertion is characteristic for the families Euglenidae and Colaciidae, but the only clue to the separation of the genus *Astasia* from the other colorless forms is the observation by Lackey (1934a) of a bifurcation. This has not yet been confirmed and certainly can not be used as a convenient family character.

The pharyngeal rod apparatus is easily identified in *Peranema*, *Heteronema* and *Entosiphon*, but is not so easily seen in other genera (e.g., *Petalomonas*), and, therefore, does not seem very useful as a family characteristic.

The criterion of symmetry used by Lemmerman (1913) for separating the Astasiidae from the Peranemidae is apparently useless. Many species are better described as asymmetrical. The genus *Rhabdomonas* differs from *Menoidium* only in that the cells are cylindrical in cross section rather than flattened (Pringsheim, 1942); these genera are obviously closely related and should not be placed in separate families.

If we define holozoic nutrition as a characteristic of the Peranemidae we have a character which is easily observable in some genera, but not so easily observed in the small genera which may ingest bacteria only a few at a time. Lemmerman (1913) lists the following genera as holozoic: *Peranema*, *Euglenopsis*, *Urceolus*, *Petalomonas*, *Scytomonas*, *Heteronema*, *Tropidoscyphus*, *Notosolenus*, *Anisonema*, *Entosiphon* (cf. Lackey, 1929a) and *Dinema*. The only other genus included in the family was *Marsupiogaster*, in which the mode of nutrition was unknown. In many cases the mode of nutrition is not easily determined by observation.

It seems as if any of these criteria will give rise to both practical and theoretical difficulties, and which group of evils will be the least is a matter of conjecture. One way out of the dilemma would be to have only one colorless family instead of two, but this would result in an unusual diversity of types within the family.

TAXONOMIC SURVEYS

The latest monographs which list all known species of the euglenoids are those of Lemmerman (1913) and Walton (1915). More recent taxonomic surveys have been limited to one genus. There are several long monographs on green genera, but there is no complete treatment of the genus *Euglena*. However, forty-one species and eleven varieties are described by Johnson (1944), and other useful descriptions are given by Drezepolski (1925), Mainx (1926, 1928), Günther (1928), and

Szabados (1936). The more common species of *Phacus* are described by Allegre and Jahn (1943), and all known species by Pochmann (1942) and Skvortzow (1928). A complete survey of the genus *Lepocinclis* was published by Conrad (1934, 1935). The genus *Trachelomonas* was surveyed by Deflandre (1926, 1926–1927, 1927) and also by Skvortzow (1925, 1926), and certain taxonomic problems were discussed by Gordienko (1929). Deflandre (1930) created the genus *Strombomonas* (*Trachelomonas pro parte*) and described all the known species (cf. Balech and Dastugue, 1938). The green genera *Eutreptiella* (= *Gymnastica* Pascher, 1927), *Chlorachne*, and *Chloranima* (= *Ottonia*, Strand, 1928) were described by Schiller (1925), and *Euglenocapsa* by Steinecke (1932). The genus *Amblyophis* is usually included in *Euglena* (cf., Bhatia, 1930), and the genus *Amphitropis* (Gicklhorn, 1920) is apparently a Phytomonad (Chodat, 1925).

There are no extensive monographs on the colorless genera. A number of carefully studied species of *Astasia*, *Distigma*, *Menoidium*, and *Rhabdomonas* (= *Menoidium pro parte*) are described by Pringsheim (1936, 1942), and a key to the genus *Peranema* is given by van Oye (1926). Two new genera (*Triangulomonas* and *Peranemopsis*) were described by Lackey (1940a), and the more common species of *Petalomonas* are described by Shawhan and Jahn (1946).

The number of species that have been described for some genera is surprisingly large. In many cases the specific differences are small, and some of the newer species will eventually be reduced to synonymy. Yet there are new species continually being described which are quite distinct from anything in the literature and which apparently will not become synonyms. The only way to be certain that minor differences are genetic is to maintain all known species in pure culture. So far this method is impracticable, but its value has been discussed by Lefèvre (1931), Pringsheim (1941), and others. The extensive collections of Pringsheim and R. P. Hall are a step in this direction.

PHYLOGENY

Most investigators seem reticent to discuss the possible phylogeny of the euglenoids and their relationship with other flagellates or algae. However, Chadefaud (1936, 1937, 1938) pointed out that they possess certain cytoplasmic structures (see mucus bodies, above), and in some cases grooves for the flagella, which he considered to indicate a relationship to the dinoflagellates. Chadefaud also discussed phylogenetic relationships within the order. Schiller (1925) has placed two green marine stigmate genera without a gullet among the euglenoids, and it seems possible that a further investigation of the cytology of the genera might shed light on the phylogenetic relationships of the group. Senn (1900) pointed out a possible relationship with the Chloromonadida because of the gullet and type of flagellum insertion. The phylogeny of the Euglenidae, especially the relationship of amoeboid to rigid species, is discussed by Elenkin (1924a, 1924b) and Mainx (1928). The genus *Colacium*, because of the predominance of palmella and stalked stages, may be considered more closely related to the algae than other members of the family Euglenidae. This idea is strengthened by the fact that the flagellum insertion is of the type postulated by Lackey (1934a) for the hypothetical ancestral euglenoid (Fig. 4, 9a), but it must also be fitted into the common concept that the algae have evolved from the flagellates. Most of the euglenoids are so specialized that there are no clear lines of development either to or from algal or other flagellate groups. After a rather extensive consideration of the subject, Fritsch (1929, 1935) carefully refrained from drawing conclusions on the phylogenetic relationships.

It is generally assumed that the colorless species arose from the green ones by loss of chlorophyll (Pringsheim, 1937, 1941) and that some of the colorless forms eventually became holozoic. However, the report by Mast and Pace (1933) that chemoautotrophic nutrition occurs in *Chilomonas* and the discovery by Schoenborn (1940) that heteroautotrophic nutrition occurs in *Astasia* makes it seem possible that some primitive colorless flagellates might have existed before the chlorophyll-bearing species. Furthermore, if one assumes that the green species occurred first, then the only necessity for a foodstuff which was introduced by the loss of chlorophyll was that of acetate or some similar simple compound (see nutrition, above). The problem of adaptation to the loss of chlorophyll was apparently a simple one. Indeed, some of the green species of *Euglena* (*E. deses*, and *E. pisciformis*) are no longer able to use inorganic nitrogen compounds and are in this respect more dependent on other organisms than is *Astasia* (discussions by Schoenborn, 1940; Hall, 1941a).

Addenda

After the above article was written, a monograph by André Hollande, entitled "Etude cytologique et biologique de quelques flagellés libres (Volvocales, Cryptomonadines, Euglèniens, Protomastigines)," (*Arch. Zool. exp. gen.*, 83: 1–268. 1942) which contains about one hundred pages on the euglenoids, became available in this country. Hollande's monograph contains a detailed discussion of mitosis and cytoplasmic inclusions based largely on his own observations. He offers a confirmation of the bifurcation of the flagellum of *Astasia* and the theory that this mode of flagellar insertion was derived by regression from that of *Euglena* (cf. Lackey, above). The paper also contains descriptions of five new species of *Petalomonas*.

Harley P. Brown (On the structure and mechanics of the protozoan flagellum, *Ohio J. Sci.*, 45: 247–278. 1945) by use of the electron microscope has confirmed the existence of mastigonemes on the euglenoid flagellum and has pointed out that the core of the flagellum of *Euglena* and of *Astasia* is double. This latter observation fits into the idea that the flagella of both genera are bifurcated. Brown also substantiates Lowndes' theory that forward movement is largely a result of gyration rather than of a direct forward component from the flagellum.

LIST OF LITERATURE

ALEXANDER, GORDON. 1931. The significance of hydrogen ion concentration in the biology of *Euglena gracilis* Klebs. *Biol. Bull.*, 61: 165–184.

ALLEGRE, C. F., and JAHN, T. L. 1943. A survey of the genus *Phacus* Dujardin (Protozoa; Euglenoidina). *Trans. Amer. micr. Soc.*, 62: 233–244.

BAAS-BECKING, LOURENS G. M., and ROSS, P. A. 1926. Notes on microspectra. I. The absorption spectrum of *Euglena*. *J. Gen. Physiol.*, 9: 111–114.

BAKER, C. L. 1933. Studies on the cytoplasmic components of *Euglena gracilis* Klebs. *Arch. Protistenk.*, 80: 434–468.

BAKER, J. R. 1944. The structure and chemical composition of the Golgi element. *Quart. J. micr. Sci.*, 85: 1–71.

BAKER, W. B. 1926 Studies on the life history of *Euglena*. I. *E. agilis* Carter. *Biol. Bull.*, 51: 321–362.

BALECH, E., and DASTUGUE, C. 1938. Nota preliminar sobre "*Strombomomas*" y "*Trachelomonas*." *Physis, B. Aires*, 12: 354–357.

BANCROFT, F. W. 1913. Heliotropism, differential sensibility and galvanotropism in *Euglena*. J. *exp. Zool.*, 15: 383–428.

BARKER, D. 1943. Recent work on flagellar movement. *New Phytol.*, 42: 49–53.

BEAMS, H. W., and KING, R. L. 1935. The effect of ultracentrifuging on the cells of the root tip of the bean (*Phaseolus vulgaris*). *Proc. roy. Soc.*, B., 118: 264–276.

BĚLAŘ, K. 1926. Der Formwechsel der Protistenkerne. *Ergebn. Fortschr. Zool.*, 6: 235–654.

BHATIA, B. L. 1930. On some fresh water rhizopods and flagellates from Kashmir. *Arch. Protistenk.*, 72: 359–364.

BIECHELER, B. 1937. Sur l'existence d'une copulation chez une euglène verte et sur les conditions globales qui la déterminent. *C. R. Soc. Biol. Paris*, 124: 1264–1266.

BRACHER, R. 1919. Observations on *Euglena deses*. *Ann. Bot.*, 33: 93–108.

——. 1929. The ecology of the Avon banks at Bristol. *J. Ecol.*, 17: 35–81.

BRADLEY, W. H. 1929. Fresh water algae from the Green River formation of Colorado. *Bull. Torrey bot. Club*, 56: 421–428.

VON BRAND, T. 1935. Der Stoffwechsel der Protozoen. *Ergebn. Biol.*, 12: 161–220.

——. 1944. Occurrence of anerobiosis among invertebrates. *Biodynamica*, 4: 185–328.

BRISCOE, M. S. 1939. A source of *Euglena*. *Trans. Amer. micr. Soc.*, 58: 374.

BROWN, V. E. 1930a. Cytology and binary fission of *Peranema*. *Quart. J. micr. Sci.*, N. S., 73: 403–419.

——. 1930b. Cytoplasmic inclusions of *Euglena gracilis* Klebs. *Z. Zellforsch. mikr. Anat.*, 11: 244–254.

BÜTSCHLI, O. 1906. Beitrage zur Kenntnis des Paramylons. *Arch. Protistenk.*, 7: 197–228.

CALKINS, G. N. 1926, 1933. *The biology of the Protozoa*. Lea and Febiger, Philadelphia. 1926, 623 pp.; 1933, XI + 607 pp.

CARTER, N. 1933. A comparative study of the algal flora of two salt marshes. II. *J. Ecol.*, 21: 128–208.

——. 1937. New or interesting algae from brackish water. *Arch. Protistenk.*, 90: 1–68.

CAUSEY, D. 1926. Mitochondria in *Euglena gracilis* Klebs. *Univ. Colo. Publ. Zool.*, 28: 217–224.

CHADEFAUD, M. 1936. Protistes trichocystifères ou Protogastréades. *Ann. Protist., Paris*, 5: 323–341.

——. 1937. Anatomie comparée des Euglèniens. *Botaniste*, Ser. 28, pp. 85–185.

CHADEFAUD, M. 1938. Nouvelles recherches sur l'anatomie comparée des Eugléniens: les Peranémines . *Rev. Algol.*, 11: 189–220.

——. 1939. Sur l'organisation d'*Euglena stellata* Mainx et sur la discrimination des Euglenes viridoides. *Arch. Zool. exp. gen., Paris*, 80: 49–54.

——. 1940. Phénomèmes sexuels chez les Eugléniens. *Rev. Sci.*, 78: 179–180.

CHADEFAUD, M., and PROVASOLI, L. 1939. Une nouvelle Eugléne graciloide; *Euglena gracilis* Klebs var. *urophora* n. var. *Arch. Zool. exp. gen., Paris*, 80: 55–60.

CHODAT, R. 1925. Observations faites à la Linnaea 1923–1925. *Bull. Soc. bot. Genève*, 17: 180–251.

CONRAD, W. 1934. Materiaux pour une Monographie du genre *Lepocinclis* Perty. *Arch. Protistenk.*, 82: 203–249.

——. 1935. Etude systematique du genre *Lepocinclis* Perty. *Mem. Mus. Hist. nat. Belg.*, 1: 1–84.

COWDRY, E. V. 1943. *Microscopic technique in Biology and Medicine.* Williams & Wilkins, Baltimore. 206 pp.

CZURDA. V. 1928. Morphologie und Physiologie des Algenstärkekornes. *Beih. bot. Zbl.*, 45: 97–270.

VON DACH, H. 1940. Factors which affect the growth of a colorless flagellate, *Astasia klebsii*, in pure cultures. *Ohio J. Sci.*, 40: 37–48.

——. 1942. Respiration of a colorless flagellate, *Astasia klebsii. Biol. Bull.*, 82: 356–371.

——. 1943. The effect of pH on pure cultures of *Euglena mutabilis. Ohio J. Sci.*, 43: 47–48.

DANGEARD, P. 1902. Recherches sur les Eugléniens. *Botaniste*, 8: 7–370.

——. 1928a. L'appareil mucifere et le vacuome chez les Eugleniens. *Ann. Protist., Paris*, 1: 69–74.

——. 1928b. Le determinisme des mouvements chez les organismes inferieurs. *Ann. Protist., Paris*, 1: 3-10.

——. 1933. *Traité d'Algologie.* Paul Lechevalier, Paris. 441 pp.

DANIELS, M. I. 1938. A cytological study of the gregarine parasites of *Tenebrio molitor*, using the ultracentrifuge. *Quart. J. micr. Sci.*, 80: 293–320.

DEFLANDRE, G. 1926. *Monographie du genre Trachelomonas Ehr.* Nemours. 162 pp.

——. 1926–1927. Monographie du genre Trachelomonas Ehr. 1926, 38: 358–380, 449–469, 518–528, 580–592, 646–658, 687–706; 1927, 39: 26–51, 73–98.

——. 1927. Remarques sur la systematique du genre *Trachelomonas* Ehr. *Bull. Soc. bot. Fr.* 74: 285–287, 657–665.

——. 1929. Observations sur les mouvements propres, pistes et vitesses de deplacement de quelques Protistes. *Ann. Protist., Paris*, 2: 1–40.

——. 1930. *Strombomonas*, nouveau genre d'Euglenacees (*Trachelomonas* Ehrb. *pro. parte*). *Arch. Protistenk.*, 69: 551–614.

——. 1931. Sur la structure de la membrane chez quelques *Phacus. Ann. Protist., Paris*, 3: 41–43.

——. 1932. Contributions à la connaissance des Flagellés libres. I. *Ann. Protist., Paris*, 3: 219–246.

——. 1934a. Sur l'abus de l'emploi, en paleontologie du nom de genre *Trachelomonas* et sur la nature de quelques ex "Trachelomonos" siliceux (Chrysomonadines) tertiaires et quaternaires. *Ann. Protist., Paris*, 4: 151–165.

——. 1934b. Sur les proprietés optiques du paramylon (Variations de l'anisotropie). *Bull. biol.*, 68: 382–384.

——. 1934c. Sur la structure des flagelles. *Ann. Protist., Paris*, 4: 31–54.

——. 1934d. Existence sur les flagelles de filaments lateraux au terminaux (mastigonèmes). *C. R. Acad. Sci., Paris*, 198: 497–499.

——. 1935. *Trachelomonas*, Archaemonadaceés et Chrysostomataceés. Résponse à une note de J. Frenguelli. *Arch. Protistenk.*, 85: 306–311.

DELLINGER, O. P. 1909. The cilium as a key to the structure of contractile protoplasm. *J. Morph.*, 20: 171–209.

DOBELL, C. C. 1908. The structure and life history of *Copromonas*, nov. gen., nov. spec.: a contribution to our knowledge of the Flagellata. *Quart. J. micr. Sci.*, 52: 75–120.

DOFLEIN, F., and REICHENOW, E. 1928–1929. *Lehrbuch der Protozoenkunde.* Gustav Fischer, Jena. 1262 pp.

DOYLE, W. L. 1943. The nutrition of the protozoa. *Biol. Rev.*, 18: 119–136.

DREZEPOLSKI, R. 1925. Supplement à la connaisance des Eugléniens de la Pologne (Polish with French summary). *Kosmos, Lwów*, 50: 173–270.

——. 1929. L'evolution du noyau et son rôle chez les Euglènes. *Ann. Protist., Paris*, 2: 109–118.

DUBOSCQ, and GRASSÉ, P. 1933. L'appareil parabasal des flagellés. *Arch. Zool. exp. gen.*, 73: 3816–21.

DUFRENOY, J. 1940. On the physiological significance of the vacuome. *Biodynamica*, 3: 171–190.

DUNHAM, D. W. 1937. The flagella of *Peranema. Science*, 85: 206.

DUSI, H. 1930. Limites de la concentration en ions H pour la culture de quelques Euglènes. *C. R. Soc. Biol. Paris*, 104: 734–736.

ELENKIN, A. A. 1924a. De Euglenarum sine flagellosectione nova. *Not. syst. Inst. crypt. Hort. Bot. Reip. Rossic*, 3: 124–160.

——. 1924b. Ueber die Stellung der cilienlosen Sektion (Amastigatae) im System der Euglènen. *Not. syst. Inst. crypt. Hort. Bot. Reip. Rossic*, 3: 161–170.

ELLIOTT, A. M. 1937. Plant hormones and growth of *Euglena* in relation to light. *Anat. Rec.*, 70 (Suppl.): 128.

——. 1938. The influence of certain plant hormones on growth of Protozoa. *Physiol. Zool.*, 11: 31–39.

ELMORE, M. E. 1928a. Antigenic properties of *Euglena gracilis*. *J. Immunol.*, 15: 21–32.

——. 1928b. The production of anaphylaxis with *Euglena gracilis* and other unicellular chlorophyll-bearing organisms. *J. Immunol.*, 15: 33–36.

ENGELMANN, T. W. 1882. Ueber Licht- und Farbenperception niederster Organismen. *Arch. ges. Physiol.*, 28: 387–400.

FAIR, G. M., and WHIPPLE, M. C. 1927. *The microscopy of drinking water*. By G. C. Whipple. John Wiley and Sons, New York, 4th ed.

FINLEY, H. E. 1930. Toleration of fresh water protozoa to increased salinity. *Ecology*, 11: 337–347.

FISCHER, A. 1894. Ueber die Geisseln einiger Flagellaten. *J. wiss. Bot.*, 26: 187–235.

FRASER, J. H. 1932. Observations on the fauna and constituents of an estuarine mud in a polluted area. *J. Marine biol. Ass. Unit. King.*, 18: 69–85.

FRITSCH, F. E. 1929. Evolutionary sequence and affinities among Protophyta. *Biol. Rev.*, 4: 103–151.

——. 1935. *The structure and reproduction of the algae*. Vol. I. Macmillan Company, New York and London. + 791 pp.

GARCIN, A. 1889. Sur le pigment de l'*Euglena sanguinea*. *J. Bot.*, 3: 189–194.

GARD, M. 1922. Recherches sur une nouvelle espèce d'Euglene (*Euglena limosa*, nov. sp.). *Bull. Soc. bot. Fr.*, 69: 184–196, 241–250, 306–313.

GATENBY, J. B., and SINGH, B. N. 1938. Golgi apparatus of *Copromonas subtilis* and *Euglena* sp. *Quart. J. micr. Sci.*, 80: 567–591.

GATENBY, J. B., SINGH, B. N., and BROWNE, K. M. R. 1938. Further notes on the association between Golgi apparatus and the vacuole system in *Euglena* and *Copromonas*. *Cellule*, 47: 227–236.

GATENBY, J. B., and SMYTH, J. D. 1940. The Golgi apparatus and pyrenoids of *Chilomonas paramecium* with remarks on the identification of *Copromonas subtilis*. *Quart. J. micr. Sci.*, 81: 595–617.

GICKLHORN, J. 1920. Ueber eine neue Euglenacee (*Amphitropis aequiciliata* nov. gen. et spec.). *Oesterr. bot. Z.* 69: 193–199.

GIMESI, N. 1930. Die Geburt von *Trachelomonas volvocina* Ehrbg. *Arch. Protistenk.*, 72: 190–197.

GOJDICS, M. 1934. The cell morphology and division of *Euglena deses* Ehrbg. *Trans. Amer. micr. Soc.*, 53: 299–310.

——. 1939. Some observations in *Euglena sanguinea* Ehrbg. *Trans. Amer. micr. Soc.*, 58: 241–248.

VAN GOOR, A. C. J. 1925. Die Euglenineae des Hollandischen Brackwassers mit besonderer Berücksichtigung ihrer Chromatophoren. *Rec. Trav. Bot. Neerl.*, 22: 292–314.

GORDIENKO, M. 1929. Zur Frage der Systematik der Gattung *Trachelomonas* Ehrenberg. *Arch. Protistenk.*, 65: 258–267.

GRASSÉ, P. P. 1925. Le vacuome et l'appareil de Golgi des Euglènes. *C. R. Acad. Sci., Paris* 181: 482–484.

——. 1926. Sur le stigma ou appareil parabasal des Euglènes. *C. R. Soc. Biol., Paris*, 94: 1012–1014.

——, and POISSON, R. 1933. Nouvelles observations sur la cytologie des Euglènes. *C. R. Soc. Biol., Paris*, 114: 662–666.

GUILLIERMOND, A., and ATKINSON, L. R. 1941. *The cytoplasm of the plant cell*. Chronica Botanica, Waltham, Mass.

GÜNTHER, FRANZ. 1928. Uber den Bau und die Lebensweise der Euglenen, besonders der Arten *E. terricola, geniculata, proxima, sanguinea*, und *lucens* nov. spec. *Arch. Protistenk.*, 60: 511–590.

HAASE, G. 1910. Studien über *Euglena sanguinea*. *Arch. Protistenk.*, 20: 47–59.

HALL, R. P. 1923. Morphology and binary fission of *Menoidium incurvum* (Fres.) Klebs. *Univ. Colo. Publ. Zool.*, 20: 447–476.

——. 1929. Reaction of certain cytoplasmic inclusions to vital dyes and their relation to mitochondria and Golgi apparatus in the flagellate *Peranema trichophorum*. *J. Morph.*, 48: 105–122.

——. 1930. Osmiphilic inclusions similar to Golgi apparatus in the flagellates, *Chromulina, Chilomonas* and *Astasia*. *Arch. Protistenk*, 69: 7–22.

——. 1931. Cytoplasmic inclusions of *Menoidium* and *Euglena*, with special reference to the vacuome and Golgi apparatus in euglenoid flagellates. *Ann. Protist., Paris*, 3: 57–68.

——. 1933a. On the relation of hydrogen-ion concentration to the growth of *Euglena anabaena* var. *minor* and *E. deses*. *Arch. Protistenk.*, 79: 239–248.

——. 1933b. The method of ingestion in *Peranema trichophorum* and its bearing on the pharyngeal rod ("Staborgan") problem in the Euglenida. *Arch. Protistenk.*, 81: 308–317.

——. 1933c. The question of the ingestion of solid particles by *Euglena*. *Trans. Amer. micr. Soc.*, 52: 220–222.

——. 1934. A note on the flagellar apparatus of *Peranema trichophorum* and the status of the family Peranemidae Stein. *Trans. Amer. micr. Soc.*, 53: 237–243.

HALL, R. P. 1936. Cytoplasmic inclusions of Phytomastigoda. *Bot. Rev.*, 2: 85–94.

——. 1937a. A note on behavior of the chromosomes in *Euglena*. *Trans. Amer. micr. Soc.*, 56: 288–290.

——. 1937b. Certain culture reactions of several species of Euglenidae. *Trans. Amer. micr. Soc.*, 56: 285–287.

——. 1937a. Growth of free living Protozoa in pure cultures. In *Culture Methods for Invertebrate Animals*, ed., J. G. Needham. Comstock Pub. Co. Ithaca, N. Y.

——. 1939. The trophic nature of the plant-like flagellates. *Quart. Rev. Biol.*, 14: 1-12.

——. 1941a. Food requirements and other factors influencing growth of Protozoa in pure cultures. In *Protozoa in Biological Research*, eds., Calkins and Summers. Columbia Univ. Press, New York.

——. 1941b. Populations of plant-like flagellates. *Amer. Nat.*, 75: 419–437.

——. 1943. Growth-factors for Protozoa. In *Vitamins and Hormones*, eds., R. S. Harris and K. V. Thimann. Academic Press, N. Y.

HALL, R. P., and JAHN, T. L. 1929a. On the comparative cytology of certain euglenoid flagellates and the systematic position of the families Euglenidae Stein and Astasiidae Bütschli. *Trans. Amer. micr. Soc.*, 48: 388–405.

——. 1929b. Dispersed stages of the stigma in *Euglena*. *Science*, 69: 522.

HALL, R. P., and NIGRELLI, R. F. 1937. A note on the vacuome of *Paramecium bursaria* and the contractile vacuole of certain ciliates. *Trans. Amer. micr. Soc.*, 56: 185–190.

HALL, R. P., and POWELL, W. N. 1927. A note on the morphology and taxonomic position of *Peranema trichophorum*. *Trans. Amer. micr. Soc.*, 46: 155–165.

——. 1928. Morphology and binary fission of *Peranema trichophorum* (Ehrb.) Stein. *Biol. Bull.* 54: 36–64.

HALL, R. P., and SCHOENBORN, H. W. 1939. Fluctuations in growth rate of *Euglena anabaena*, *E. gracilis*, and *E. viridis*, and their apparent relation to initial density of population. *Physiol. Zool.*, 12: 201–208.

HALL, S. R. 1931. Observations on *Euglena leucops* n. sp., a parasite of *Stenostomum* with special reference to nuclear division. *Biol. Bull.*, 60: 327–334.

HAMBURGER, C. 1911. Studien über *Euglena Ehrenbergii*, insbesondere uber die Körperhulle. *S. B. heidelberg. Akad. Wiss.*, 4: 1–22.

HÄRDTL, H. 1935. Einiges uber den Bau und die Lebensweise einer neustonbildenden roten *Euglena Ehrenb*. *Beih. bot. Zbl.*, A., 53: 606–619.

HARTMANN, M., and CHAGAS, C. 1910. Flagellaten-Studien. *Mem. Inst. Osw. Cruz.*, 2: 64–125.

HASSETT, C. C. 1944. Photodynamic action in the flagellate *Peranema trichophorum* with special reference to motor response to light. *Physiol. Zool.*, 17: 270–277.

HAYE, A. 1930. Ueber den Exkretionsapparat bei den Protozoen, nebst Bemerkungen über einige andere feinere Strukturverhältnisse der untersuchten Arten. *Arch. Protistenk.*, 70: 1–87.

HEIDT, K. 1934. Hämatochromwanderung bei *Euglena sanguinea* Ehbg., *Ber. disch. bot. Ges.*, 52: 607–613.

——. 1937. Form und Struktur der Paramylonkorner von *Euglena sanguinea* (Ehrb.). *Arch. Protistenk.*, 88: 127–142.

HIBBARD, H. 1945. Current status of our knowledge of the Golgi apparatus in the animal cell. *Quart. Rev. Biol.*, 20: 1–19.

HIRSCH, G. C. 1939. *Form und Stoffwechsel der Golgi-Körper*. *Protoplasma Monog.*, 18: 394 pp.

HOLLANDE, A. 1938. Les dictyosomes des euglèniens. *C. R. Soc. Biol. Paris*, 127: 517–518.

——. 1940. Le chondriome des Eugléniens et des Cryptomonadines. *C. R. Acad. Sci., Paris*, 210: 317–319.

HYMAN, L. H. 1936. Observations on protozoa. I. The impermanence of the contractile vacuole in *Amoeba vespertilio*. II. Structure and mode of food ingestion in *Peranema*. *Quart. J. micr. Sci.*, 79: 43–56.

——. 1937. *Peranema* and "Grantia." *Science*, 85: 454.

——. 1938. Observations on Protozoa. III. The vacuolar system of the Euglenida. *Beih. bot. Zbl.*, 58A: 379–382.

IVANIC, M. 1935. Zur Kenntnis der rhizopodialen Nahrungsaufnahme bei *Peranema trichophorum* Stein. *Zool. Anz.*, 109: 19–23.

JAHN, T. L. 1929. Studies on the physiology of the euglenoid flagellates. I. The relation of the density of population to the growth rate of *Euglena*. *Biol. Bull.*, 57: 81–106.

——. 1930. Studies on the physiology of the euglenoid flagellates. II. The autocatalytic equation and the question of an autocatalyst in the growth of *Euglena*. *Biol. Bull.*, 58: 281–287.

——. 1931. Studies on the physiology of the euglenoid flagellates. III. The effect of hydrogen ion concentration on the growth of *Euglena gracilis* Klebs. *Biol. Bull.*, 61: 387–399.

——. 1933a.—Studies on the physiology of the euglenoid flagellates. IV. The thermal death time of *Euglena gracilis*. *Arch. Protistenk.*, 79: 249–262.

——. 1933b. On certain parasites of *Phacus* and *Euglena*; Sphaerita phaci, sp. nov. *Arch. Protistenk.*, 79: 349–355.

——. 1934. Problems of population growth in the Protozoa. *Cold Spring Harbor Symp. Quant. Biol.*, 2: 167–180.

——. 1935. Studies on the physiology of the euglenoid flagellates. VI. The effects of temperature and of acetate on Euglena gracilis cultures in the dark. *Arch. Protistenk.*, 86: 251–257.

——. 1941. Respiratory metabolism. In *Protozoa in Biological Research*, eds., Calkins and Summers. Columbia Univ. Press, New York.

JAHN, T. L., and MCKIBBEN, W. R. 1937. A colorless euglenoid flagellate, *Khawkinea halli*, n. gen., n. sp. *Trans. Amer. micr. Soc.*, 56:48–54.

JANDA, V. and JÍROVEC, O. 1937. Ueber künstlich hervorgerufenen Parasitismus eines freilebenden Ciliaten *Glaucoma piriformis* und Infektionsversuche mit *Euglena gracilis* und *Spinochaeta biflexa*. *Mem. Soc. Zool. Tchécoslov. Prague*, 5: 24 pp.

JENNINGS, H. S. 1904. Contributions to the study of the behavior of lower organisms. *Carnegie Instit. Wash. Publ.*, 16. 256 pp.

JENNINGS, H. S. 1906. *Behavior of the lower organisms*. Columbia Univ. Press, New York. 366 pp.

JÍROVEC, O. 1926. Protozoenstudien. I. *Arch. Protistenk.*, 56: 280–289.

——. 1929. Die Silberlinien bei einigen Flagellaten. *Arch. Protistenk.*, 68: 209–214.

——. 1934a. Der Einfluss von ultravioletten Strahlen auf grüne und farblose Stamme von *Euglena gracilis*. *Protoplasma*, 21: 577–587.

——. 1934b. Vorlaufige Mitteilung uber den Einfluss verschiedener Metalle auf Reinkulturen von *Euglena gracilis*. *Mem. Soc. Zool. Tchécoslov. Prague*, 2: 6 pp.

JÍROVEC, O., and VÁCHA, K. 1934a. Ueber die Schutzwirkung von Germanin gegen photodynamische Schadigung und ultraviolette Strahlen. *Mem. Soc. Zool. Tchécoslov. Prague*, 2: 11 pp.

——. 1934b. Photodynamische erscheinungen an grünen und farblosen Stamm von *Euglena gracilis*. *Protoplasma*, 22: 203–208.

JOHNSON, D. F. 1934. Morphology and life history of *Colacium vesiculosum* Ehrbg. *Arch. Protistenk.*, 83: 241–263.

JOHNSON, L. P. 1939. A study of *Euglena rubra* Hardy 1911. *Trans. Amer. micr. Soc.*, 58: 42–48.

——. 1942. A peculiar staining reaction in *Euglena rubra* Hardy 1911. *Proc. Iowa Acad. Sci.*, 49: 517–519.

——. 1944. Euglenae of Iowa. *Trans. Amer. micr. Soc.*, 63: 97–135.

JOHNSON, L. P., and JAHN, T. L. 1942. Cause of the green-red color change in *Euglena rubra*. *Physiol. Zool.*, 15: 89–94.

JONES, D. T. 1944. Two protozoans from Great Salt Lake. *Bull. Univ. Utah.* (Biol. Ser.), 35: 11 pp.

KAHL, A. 1928. Die Infusorien (Ciliata) der Oldesloer Salzwasserstellen. *Arch. Hydrobiol.*, 19: 50–123.

KIDDER, G. W. 1941. The technique and significance of control in protozoan culture. In *Protozoa in Biological Research*, eds., Calkins and Summers. Columbia Univ. Press, New York.

KING, R. L. 1935. The contractile vacuole of *Paramecium multimicronucleata*. *J. Morph.*, 58: 555–571.

KIRBY, H. 1941a. Relationships between certain Protozoa and other animals. In *Protozoa in Biological Research*, eds., Calkins and Summers. Columbia Univ. Press, New York. Pp. 890–1008.

——. 1941b. Organisms living on or in Protozoa. In *Protozoa in Biological Research*, eds., Calkins and Summers. Columbia Univ. Press, New York. Pp. 1009–1114.

KIRKMAN, H., and SEVERINGHAUS, A. E. 1938. A review of the Golgi apparatus. *Anat. Rec.*, 70: 413–432, 557–573; 71: 79–103.

KLEBS, G. 1883. Uber die Organisation einiger Flagellatengruppen und ihre Beziehungen zu anderen Infusorien. *Untersuch. bot. Inst. Tübingen*, 1: 233–362.

KLEIN, B. M. 1930. Ueber das Silberliniensystem einiger Flagellaten. *Arch. Protistenk.*, 72: 404–419.

KOL, E. 1929. "Wasserblute" der Sodateiche auf der Nagy Magyar Alfold (Grossen Ungarischen Tiefebene). *Arch. Protistenk.*, 66: 515–522.

KORSCHIKOW, A. 1923. Ueber den Bau und die Aggregation der Geisseln bei den Volvocales und den Flagellaten. *Arch. Russ. Protist.*, 2: 195–205.

——. 1924. Ueber den Bau und die Aggregation der Geisseln bei den Volvocales und den Flagellaten. *Arch. Russ. Protist.*, 3: 148–205.

KRICHENBAUER, H. 1937. Beitrag zur Kenntnis der Morphologie und Entwicklungsgeschichte der Gattung *Euglena* und *Phacus*. *Arch. Protistenk.*, 90: 88–123.

KUDO, R. R. 1946. *Protozoology*. C. C. Thomas, Springfield and Baltimore. 778 pp.

KUTSCHER, F. 1898. Beitrage zur Kenntnis der *Euglena sanguinea*. *Z. physiol. Chem.*, 24: 360–363.

KYLIN, H. 1927. Ueber die karotinoiden Farbstoffe der Algen. *Hoppe-Seyl. Z.*, 166: 39–77.

LACKEY, J. B. 1929a. Studies on the life histories of Euglenida. I. The cytology of *Entosiphon sulcatum* (Duj.) Stein. *Arch. Protistenk.*, 66: 176–200.

——. 1929b. Studies in the life histories of Euglenida. II. The life cycles of *Entosiphon sulcatum*

and *Peranema trichophorum*. *Arch. Protistenk.*, 67: 128–156.

LACKEY, J. B. 1932. Oxygen deficiency and sewage protozoa: with descriptions of some new species. *Biol. Bull.*, 63: 287–295.

——. 1933. Studies in the life history of the Euglenida. III. The morphology of *Peranema trichophorum* Ehrenberg, with special reference to its kinetic elements and the classification of the Heteronemidae. *Biol. Bull.*, 65: 238–248.

——. 1934a. Studies in the life histories of Euglenida. IV. A comparison of the structure and division of *Distigma proteus* Ehrenberg and *Astasia dangeardi* Lemm. A study in phylogeny. *Biol. Bull.*, 67: 145–161.

——. 1934b. Two new species of Euglenidae and the position of the order. *J. Tenn. Acad. Sci.*, 9: 31–33.

——. 1936. Occurrence and distribution of the marine protozoan species in the Woods Hole area. *Biol. Bull.*, 70: 264–278.

——. 1938a. The flora and fauna of surface waters polluted by acid mine drainage. *U. S. Pub. Health Rep.*, 53: 1499–1507.

——. 1938b. A study of some ecologic factors affecting the distribution of Protozoa. *Ecol. Monog. Durham*, 8: 501–527.

——. 1939a. Notes on plankton flagellates from the Scioto River (with descriptions of new forms). *Lloydia, Cincinnati*, 2: 128–143.

——. 1939b. Aquatic life in waters polluted by acid mine waste. *U. S. Pub. Health Rep.*, 54: 740–746.

——. 1940. Some new flagellates from the Woods Hole area. *Amer. Midl. Nat.*, 23: 463–471.

——. 1940b. The microscopic flora and fauna of tree holes. *Ohio J. Sci.*, 40: 186–192.

——. 1942. The effects of distillery wastes and waters on the microscopic flora and fauna of a small creek. *U. S. Pub. Health Rep.*, 57: 253–260.

LACKEY, J. B., and SMITH, R. S. 1940. Limitations of Euglenidae as polluted water indicators. *U. S. Pub. Health. Rep.*, 55: 268–280.

LEFÈVRE, M. 1931. De la valeur des caractères spécifiques chez quelques Eugléniens. *Rec. Trav. Crypt. dédiés à L. Mangin, Paris*. Pp. 343–354.

——. 1932a. Sur la structure de la membrane des Euglènes du groupe Spirogyra. *C. R. Acad. Sci. Paris*, 195: 1908–1309.

——. 1932b. Sur le déterminisme des variations morphologique et ornementales chez quelques Eugléniens. *Ann. Protist., Paris*, 3: 201–207.

——. 1932c. Recherches sur la biologie et la systématique de quelques algues obtenues en cultures. *Rev. Algol.*, 6: 313–335.

——. 1934. Recherches sur la biologie et la systématique de quelques Eugléniens. *Rev. Algol.*, 7: 139–148.

LEMMERMANN, E. 1906. Ueber das Vorkommen von Süsswasserformen in Phytoplankton des Meeres. *Arch. Hydrobiol.*, 1: 409–427.

——. 1913. Eugleninae. In *Die Süsswasserflora Deutschlands, Osterreich und der Schweiz*, Fischer, Jena. 2: 115–174.

LINDEMAN, R. L. 1942. Experimental simulation of winter anaerobiosis in a senescent lake. *Ecology*, 23: 1–13.

LOEFER, J. B. 1931. Morphology and binary fission of *Heteronema acus* (Ehrb) Stein. *Arch. Protistenk.*, 74: 449–470.

——. 1939. Acclimatization of fresh water ciliates and flagellates to media of higher osmotic pressure. *Physiol. Zool.*, 12: 161–172.

LOWNDES, A. G. 1941. On flagellar movement in unicellular organisms. *Proc. zool. Soc. Lond.*, 111A: 111–134.

——. 1944. The swimming of unicellular flagellate organisms. *Proc. zool. Soc. Lond.*, 113A; 99–107.

LWOFF, A. 1933. Die Bedeutung des Blutfarbstoffes für die parasitischen Flagellaten. *Zbl. Bakt. Abt. (Orig.)*, 130: 498–518.

LWOFF, A., and DUSI, H. 1935. La suppression experimentale des chloroplastes chez *Euglena mesnili*. *C. R. Soc. Biol. Paris*, 119: 1092–1095.

——. 1936. La nutrition de l'Euglénien *Astasia chattoni*. *C. R. Acad. Sci. Paris*, 202: 248–250.

LUND, J. W. G. 1942. The marginal algae of certain ponds, with special reference to bottom deposits. *J. Ecol.* 30: 245–283.

MACLENNAN, R. F. 1941. Cytoplasmic inclusions. In *Protozoa in Biological Research*, ed. by Calkins and Summers. Columbia Univ. Press, New York. Pp. 111–190.

MAINX, F. 1926. Einige neue Vertreter der Gattung *Euglena* Ehrb. *Arch. Protistenk.*, 54: 150–160.

——. 1928. Beiträge zur Morphologie und Physiologie der Engleninen. *Arch. Protistenk.*, 60: 305–414.

MANGENOT, G. 1926. À propos de la signification du stigma des Englènes. *C. R. Soc. Biol. Paris*, 94: 577.

MAST, S. O. 1911. *Light and the behavior of organisms*. New York, 410 pp.

——. 1917. The relation between spectral color and stimulation in the lower organisms. *J. exp. Zool.* 22: 471–528.

——. 1927. Structure and function of the eyespot in unicellular and colonial organisms. *Arch. Protistenk.*, 60: 197–220.

——. 1936. Motor responses to light in the invertebrate animals. In *Biological Effects of Radiation*, ed. by B. M. Duggar. McGraw-Hill Company, New York.

——. 1941. Motor response in unicellular animals. In *Protozoa in Biological Research*, Calkins and Summers, eds. Columbia Univ. Press, New York. Pp. 271–351.

——, and DOYLE, S. L. 1935. A new type of cytoplasmic structure in the flagellate *Chilomonas paramecium*. *Arch. Protistenk.*, 85: 145–149.

——, and GOVER, MARY. 1922. Relation between intensity of light and rate of locomotion in *Phacus pleuronectes* and *Euglena gracilis* and its bearing on orientation. *Biol. Bull.*, 43: 203–209.

——, and PACE, D. M. 1933. Synthesis from inorganic compounds of starch, fats, proteins and protoplasm in the colorless animal *Chilomonas paramecium*. *Protoplasma*, 20: 326–358.

MOLISCH, H. 1923. *Mikrochemie der Pflanze*. 3rd Ed. Jena.

NASSONOV, D. 1924. Der Exkretionsapparat (kontractile Vacuole) der Protozoa als Homologon des Golgischen Apparats der Metazoazellen. *Arch. mikr. Anat.*, 103: 437–482.

NAUMANN, E. 1922. Die Sestonfarbungen des Süsswassers, etc. *Arch. Hydrobiol.*, 13: 647–692.

VAN OYE, PAUL. 1926. Flagellates du Congo Belge. *Bull. Soc. roy. Bot. Belg.*, 58: 11–19.

PASCHER, A. 1927. Neue oder wenig bekannte Flagellaten XVIII. *Arch. Protistenk.*, 58: 577–598.

——. 1930. Eine neue, stigmatisierte und phototaktische Amöbe. *Biol. Zbl.*, 50: 1–7.

——. 1931. Ueber die Verfestigung des Protoplasten im Gehause einer neuen Euglenine (*Klebsiella*). *Arch. Protistenk.*, 73: 315–322.

PATTEN, RUTH, and BEAMS, H. W. 1936. Observations on the effect of the ultra-centrifuge on some free-living flagellates. *Quart. J. micr. Sci.*, 78: 615–635.

PETERSEN, J. B. 1929. Beitrage zur Kenntnis der Flagellatengeisseln. *Bot. Tidsskr.*, 40: 373–389.

POCHMANN, A. 1942. Synopsis der Gattung *Phacus*. *Arch. Protistenk.*, 95: 81–252.

PRINGSHEIM, E. G. 1926. Ueber das Ca-Bedurfnis einiger Algen. *Planta*, 2: 555–568.

——. 1935. Ueber Azetatflagellaten. *Naturwiss.*, 23: 110–114.

——. 1936. Zur Kenntnis saprotroper Algen und Flagellaten. I. Ueber Anhäufungskulturen polysaprober Flagellaten. *Arch. Protistenk.*, 87: 43–96.

——. 1937. Ueber das Stigma bei farblosen Flagellaten. *Cytologia*, Fujii-Festschrift, pp. 324–255.

——. 1941. The interrelationships of pigmented and colourless Flagellata. *Biol. Rev.*, 16: 191–204.

——. 1942. Contributions to our knowledge of saprophytic algae and flagellata. III. *Astasia*, *Distigma*, *Menoidium*, and *Rhabdomonas*. *New Phytol.*, 41: 171–205.

RATCLIFFE, H. 1927. Mitosis and cell division in *Euglena spirogyra*. *Biol. Bull.*, 53: 109–122.

REUKAUF, E. 1940. Ueber Trichozysten bei Ziliaten und ähnliche Gebilde bei Flagellaten. *Mikrokosmos*, 33: 77–80.

RHODES, R. C. 1926. Mouth and feeding habits of *Heteronema acus*. *Anat. Rec.*, 34 (Suppl.): 152–153.

RYBINSKY, S. B., and ZRYKINA, L. M. 1935. Ueber Kernveränderung bei *Euglena gracilis* (Ehrbg) bei chronischer Arsenvergiftung. *Arch. Protistenk.*, 85: 334–340.

SANDON, H. 1927. *The composition and distribution of the protozoan fauna of the soil*. Oliver and Boyd, London, xv + 237 pp.

SANDS, W. N. 1934. The coloured scums of padi fields. *Malay. agric. J.*, 22: 484.

SAUER, M. E. 1935a. The cytotoxic principle in anti-euglena rabbit serum. *J. Immunol.*, 29: 157–164.

——. 1935b. Correlation of immunologic and physiologic types of *Euglena gracilis* Klebs. *Arch. Protistenk.*, 85: 412–415.

SCHILLER, J. 1925. Die planktonischen Vegetationen des adriatischen Meeres. B. Chrysomonadina, Heterokontae, Cryptomonadina, Eugleniae, Volvocales. *Arch. Protistenk.*, 53: 49–123.

SCHOENBORN, H. W. 1936. Growth of two species of Astasia in relation to pH of the medium. *Anat. Rec.*, 67 (Suppl.): 121.

——. 1940. Studies on the nutrition of colorless euglenoid flagellates. I. Utilization of inorganic nitrogen by *Astasia* in pure cultures. *Ann. N. Y. Acad. Sci.*, 40: 1–36.

——. 1942. Studies on the nutritional requirements of *Euglena gracilis* in darkness. *Physiol. Zool.*, 15: 325–332.

SCHRÖDER, V. N. 1927. Influence of electrolytes upon the difference of potential of the cell wall in *Euglena ehrenbergii*. (In Russian). *Proc. 2nd Cong. Zool. Anat. Histol. U.S.S.R.*, 167–168.

SENIOR-WHITE, R. 1928. Physical factors in mosquito ecology. II. *Ind. J. med. Res.*, 16: 11–30.

SENN, G. 1900. Eugleninae, in *Naturl. Pflanzenfam.* 1st ed. 1, la, pp. 173–185.

SHAWHAN, F. M., and JAHN, T. L. 1946. A study of the genus *Petalomonas*. (In press)

SHORTESS, G. S. 1942. The relation between temperature, light, and rate of locomotion in *Peranema trichophorum* and response to changes in temperature. *Physiol. Zool.*, 15: 184–195.

SIGOT, A. 1931. Existence de plaquettes osmiophiles periflagellaires chez *Euglena gracilis* Klebs; leur valeur cytologique. *C. R. Soc. Biol. Paris*, 106: 1069–1072.

SINGH, J. 1941. Soil algae of Lahore. *Current Sci., Bangalore*, 10: 29–30.

SKVORTZOW, B. W. 1925. Die Euglenaceengattung *Trachelomonas* Ehrenberg. Eine systematische Ubersicht. *Tr. Sungariiskoe Rech. Biol. Sta.*, 1: 1–101.

——. 1926. Ueber neue und wenig bekannte Formen der Euglenaceengattung *Trachelomonas* Ehrenb. II. *Ber. dtsch. bot. Ges.*, 44: 603–621.

——. 1928. Die Englenaceeangattung *Phacus* Dujardin. *Ber. dtsch. bot. Ges.*, 46: 105–125.

SMITH, G. M. 1933. *The fresh-water algae of the United States*. McGraw-Hill, New York. 716 pp.

SMYTH, J. D. 1943. Golgi apparatus in *Astasia harrisii*. *Nature, Lond.*, 151: 110.

——. 1944. The Golgi apparatus of Protozoa. *Biol. Rev.*, 19: 94–104.

SOKOLOFF, D. 1933. Algunas nuevas formas de flagelados del Valle de Mexico. *Ann. Inst. Biol. Mex.*, 4: 197–206.

——. 1935a. Contribucion al conocimiento de la estructura del estigmata de los Euglenoidina. *Ann. Inst. Biol. Mex.*, 6: 71–78.

——. 1935b. El organoide de percepciones luminosas de los Euglenoidina. *Ann. Inst. Biol. Mex.*, 6: 189–192.

SPARROW, F. K. 1943. *Aquatic Phycomycetes*. Univ. of Mich. Press, Lansing. 785 pp.

STEINECKE, F. 1925. Der Stammbaum der Algen nach sero-diagnostischen Untersuchungen dargestellt. *Bot. Arch.*, 10: 82–205.

——. 1932. Algologische Notizen II. *Heterodendron Pascheri, Euglenocapsa ochracea, Stylodinium cerasiforme*. *Arch. Protistenk.*, 76: 589–594.

STEUER, A. 1904. Ueber eine Euglenoide (*Eutreptia*) aus dem Canale Grande von Triest. *Arch. Protistenk.*, 3: 126–137.

STRAND, E. 1928. Miscellanea nomenclatorica zoologica et palaeontologica I–II. *Arch. Naturgsch.*, A., 92: 30–75.

SWANN, W. F. G., and DEL ROSARIO, C. 1931. The effect of radioactive radiations upon Euglena. *J. Franklin Inst.*, 211: 303–317.

——. 1932. The effect of certain monochromatic ultraviolet radiation on *Euglena* cells. *J. Franklin Inst.*, 213: 549–560.

SWEET, H. E. 1939. A micropopulation study of *Euglena gracilis* Klebs in sterile, autotrophic media and in bacterial suspensions. *Physiol. Zool.*, 12: 173–200.

SWIRENKO, D. K. 1927. Systematics of Euglenaceae (Russ. with Fr. summary). *Arch. russ. Protist.*, 6: 195–207.

SZABADOS, M. 1936. *Euglena* Untersuchungen. (Ger. summary). *Acta Biol. Szeged.*, 4: 45–95.

TANNREUTHER, G. W. 1923. Nutrition and reproduction of *Euglena*. *Arch. Entw. Mech. Org.*, 52: 367–383.

TANZER, C. 1941. Serological studies with free-living Protista. *J. Immunol.*, 42: 291–312.

TCHAKHOTINE, S. 1936a. La fonction du stigma chez le flagellé *Euglena*, etudiée au moyen de la micropuncture ultraviolette. *C. R. Soc. Biol. Paris*, 121: 1162–1165.

——. 1936b. Les Protozoaires, objets d'experiences en Cytologie experimentale. (Recherches faites avec la micropuncture ultraviolette). *Ann. Protist.*, 5: 1–57.

TERNETZ, CHARLOTTE. 1912. Beiträge zur Morphologie und Physiologie der *Euglena gracilis*. *Jb. wiss. Bot.*, 51: 435–514.

TISCHER, J. 1936. Ueber das Euglenarhodon und andere Carotinoide einer roten Euglene. *Hoppe-Seyl. Z.*, 239: 257–269.

TSCHENZOFF, B. 1916. Die Kernteilung bei *Euglena viridis* Ehrbg. *Arch. Protistenk.*, 36: 137–173.

VALKANOV, A. 1934. Protistenstudien IX. Eine rhizopodiale *Euglena*? *Arch. Protistenk.*, 83: 367–370.

VLK, W. 1938. Ueber den Bau der Geissel. *Arch. Protistenk.*, 90: 448–488.

WAGER, H. 1899. On the eyspot and flagellum in *Euglena viridis*. *J. Linn. Soc. Zool. Lond.*, 27: 463–481.

WALTON, L. B. 1915. Euglenoidina of Ohio. *Ohio Biol. Surv. Bull.*, 4: 341–459.

WARDEN, C. F., JENKINS, T. N., and WARNER, L. H. 1940. *Comparative Psychology*, Vol. II. Ronald Press, New York. 1070 pp.

WEATHERBY, J. H. 1941. The contractile vacuole. In *Protozoa in Biological Research*, eds. Calkins and Summers. Columbia Univ. Press, New York. Pp. 404–447.

WENRICH, D. H. 1924. Studies on *Euglenamorpha hegneri*, n.g., n. sp. *Biol. Bull.*, 47: 149–175.

——. 1935. Host-parasite relations between parasitic Protozoa and their hosts. *Proc. Amer. phil. Soc.*, 75: 605–650.

WERMEL, E. 1924a. Zur Biologie der Flagellaten eines Moortumpels. *Arch. Protistenk.*, 48: 207–212.

——. 1924b. Neue oder wenig bekannte Protisten. XII. *Arch. Protistenk.*, 48: 204–206.

DE WILDEMAN, E. 1894. Sur le thermotaxisme des euglènes. *Bull. Soc. belg. Micr.*, 20: 245–258.

——. 1928. À propos du thermatoxisme des Euglènes. *Ann. Protist., Paris*, 1: 127–136.

WILSON, C. N. 1928. The cytology and reproduction of the flagellate *Trachelomonas volvocina*. *Trans. Amer. micr. Soc.*, 47: 434–443.

VON WITTICH. 1863. Ueber den Farbstoff der *Euglena sanguinea*. *Virchows Arch.*, 27: 573–575.

ZUMSTEIN, H. 1900. Zur Morphologie und Physiologie der *Euglena gracilis*. *Jb. wiss. Bot.*, 34: 149–198.

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to B. H. Willier, Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, Homewood Campus, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

SCIENCE AND THE SOCIAL ORDER. *'Looking Forward' Pamphlets, Number 6.*

By Cecil H. Desch. Royal Institute of International Affairs, London and New York. 25 cents (paper). 49 pp. 1946.

Desch has written a thoughtful and provocative consideration of the need for increasing the role of science in national and international planning. The central idea runs as follows: "Progress in the understanding of science and the part it plays in modern civilization has not kept pace with the growing use and appreciation of the products of science. . . . . For this neglect the educational system is mainly responsible, science being looked upon as a part of professional training rather than as an element in the education of the ordinary citizen or even of those destined to hold high posts in administration. At the university level scientific education often tends to be unduly narrow. . . ."

ECOLOGY

RECENT ADVANCES IN THE CHEMISTRY AND BIOLOGY OF SEA WATER.

By H. W. Harvey. Cambridge, at the University Press; The Macmillan Company, New York. $2.75. vii + 164 pp. 1945.

Harvey's small and concise book is remarkably timely, appearing as we are taking stock of our present knowledge and are preparing to resume oceanographic research after a long interruption. The title is, however, somewhat more comprehensive than the contents. The author discusses fully and clearly all recent work dealing with the minor and biologically important constituents of sea water, but does not treat the general chemistry. Similarly, he is concerned mainly with the essential producers of organic matter, the phytoplankton, and with the organisms that break down the organic compounds, the bacteria, and does not deal with the general biology of the sea.

The numerous details in the book and the long lists of references testify to the intensity with which studies of fundamental importance to the economy of the sea have been conducted, but in spite of which our knowledge is still fragmentary and incomplete. Harvey's summary is particularly stimulating because it is always critical and never dogmatic. Thus, when discussing the controversial question of the productivity of tropical waters relative to that of waters in middle and higher latitudes, Harvey reviews all available information and gives only an indication of his own evaluation of the data. It is also gratifying that, when dealing with the biological features, the author cautions against using results of laboratory experiments for interpreting observed conditions in the ocean, and that he underlines the difficulty in carrying out significant experiments at sea.

The reviewer objects to a few statements which apparently have been made because the stationary character of the distribution of elements in the sea has not been clearly recognized. Thus, where the distribution of oxygen is stationary, consumption must exactly balance the replenishment by mechanical processes, and an oxygen minimum cannot be accounted for by excess of consumption (p. 47). Similarly, if the total amount of phosphate in the Mediterranean remains constant, there can be no continuous loss of phosphate by outflow of deep water along the bottom of the Straits of Gibraltar.

These objections are minor and do not reduce the value of the wealth of material which has been made available to all students of the sea, and the critical discussions of methods of observations and of results.

The very last page of the book contains a few sentences of particular interest to American readers. The author states that "fluctuations in fish populations where the great commercial fisheries operate have been

the subject of investigations for many years . . . it is now possible . . . to gauge the extent of fishing which would give the maximum return for human effort without unduly depleting the stock." This statement, which must apply to the fisheries around the British Isles, should serve to stimulate fisheries research off our coasts, where much still has to be learned. This research must include studies of the chemistry and biology of the sea as discussed by Harvey.

H. U. SVERDRUP

THE WORK OF THE CARNEGIE AND SUGGESTIONS FOR FUTURE SCIENTIFIC CRUISES. *Scientific Results of Cruise VII of the Carnegie during 1928–1929 under Command of Captain J. P. Ault. Oceanography—IV. Department of Terrestrial Magnetism, Carnegie Institution of Washington Publication 571.*

By James P. Ault, J. Harland Paul, John A. Fleming, Erik G. Moberg, Scott E. Forbush, Earnest S. Shepherd, and Ruth M. Crow. Carnegie Institution of Washington, Washington. $2.00 (cloth); $1.50 (paper). vii + 111 pp. 1946.

EVOLUTION

LIFE THROUGH THE AGES.

Written and illustrated by Charles R. Knight. Alfred A. Knopf, New York. $2.00. 67 pp. 1946.

Another series of pictures by the veteran artist of fossil animals is always welcome. These have all the vivid characterization and scientific plausibility of his previous paintings and drawings. Some of the sketches reproduced here have a quite familiar look, being modifications of some of the series of paintings made for the National Geographic Society some years ago, or of the well-known pictures in the American Museum of Natural History and the Field Museum. Others in the book are altogether new, particularly the drawings of related fossil and modern types combined in a single plate, and those of modern forms alone, such as the tiger, elephant, and gorilla. The 33 plates are each accompanied by a page of text, written, it would seem, for the 12-year-old. The first eleven plates form a chronological series running through the Mesozoic Era, the remainder dealing with Cenozoic and Recent birds and mammals and being arranged principally by types. For example, a plate showing *Moeritherium*, an early mastodon, and a mammoth is followed by a picture of the woolly mammoth being hunted by early man, and that by a plate showing the two species of modern elephants.

There are a few minor lapses, such as putting the Permian labyrinthodont *Eryops* into a plate of the Carboniferous Period and in showing crinoids in the Cambrian. To be sure, these forms may have existed in the earlier periods; yet our knowledge does not reach so far at the present time. In any case, this is a fine book of pictures that will make the story of evolution come alive for the youngster, and be of value for reference even to the college student or the adult with an awakening interest in the panorama of animal evolution.

BENTLEY GLASS

AMERICAN OLD AND MIDDLE TERTIARY LARGER FORAMINIFERA AND CORALS. *Part I. American Paleocene and Eocene Larger Foraminifera, by Thomas Wayland Vaughan. Part II. West Indian Eocene and Miocene Corals, by John West Wells. Geological Society of America Memoir 9.*

Geological Society of America, New York. $2.65. I, x + 175 pp.; 46 plates. II, iii + 25 pp.; 3 plates. 1945.

The title of this memoir is most misleading. Vaughan's part consists of two papers: "Paleocene and Eocene Larger Foraminifera from Barbados," and "Catalogue of American Discocyclinidae." Thus there are no middle Tertiary Foraminifera described, and other than the one family Discocyclinidae, the only forms discussed are from the one island of the West Indies. Wells describes two corals from the Miocene of the island of Martinique, and twenty-seven from the Eocene, Upper Scotland formation of the Barbados.

By far the most valuable portion of the work is Vaughan's Catalogue of American Discocyclinidae. This contains a discussion of important morphologic features, particularly those of significance in classification. The specific descriptions are unfortunately limited in number, and in no sense complete; the final section discussing the stratigraphic and geographic distribution of the American Discocyclinidae is, however, complete and detailed, and with the appended bibliographic references makes up, in part at least, for the lack of specific description.

One cannot help but wonder, however, why three essentially short reports on such diverse subjects were gathered together and dignified with such an excellent binding.

H. E. VOKES

STUDY AND REVISION OF ARCHIMEDES (HALL). *Geological Society of America Special Papers, Number 53.*

By G. E. Condra and M. K. Elias. The Geological Society of America, New York. $2.50 (paper). viii + 243 pp.; 41 plates. 1944.

This work is a comprehensive study of the morphology, occurrence, biological relations, and taxonomy of the group of Paleozoic fossils that are commonly referred

to the genus *Archimedes*. The fossil consists of a net-like frond that grew outward from the edges of a calcareous Archimedes-type screw. It has been the usual practice to assign the form to the Bryozoa. The authors, however, advance the novel concept that the frond is bryozoan, but that the screw is algal in origin, the whole being a bryozoan-algal consortium. When separated from the screw, the bryozoan frond so exactly resembles the Middle Silurian to Permian genus *Fenestella* Lonsdale that they cannot be separated, and have always been referred to that genus. (*Fenestella* Bolten, 1798, does not comply with the requirements of the International Rules of Zoological Nomenclature, and therefore does not invalidate *Fenestella* Lonsdale, 1839). One upper Silurian and one lower Devonian form of *Fenestella*-like bryozoa have been reported that showed distinct helicoid coiling with the development of a thin central shaft. These have been referred to the genus *Helicopora*. True *Archimedes* shafts, however, do not occur before the post-Kinderhookian Mississippian, when they appear in abundance, thirty or more species being found in the higher Mississippian strata. In the post-Mississippian strata of North America, it is found in only one, a lower Pennsylvanian, formation in Utah, but the genus appears to have persisted on into the lower Permian of Russia.

It is not possible within the limits of this review to discuss the evidence offered by the authors in support of the bryozoan-algal consortium hypothesis. Their conclusion that the central screw is algal in origin is based primarily upon study of the texture of the column, and the microstructure of the tissue is discussed in detail. A further report by the junior author is promised that will present a "comparative analysis of the structure in *Archimedes* and in the living and well-established fossil algae."

Condra and Elias summarize their concept of the development of the consortium as follows: (p. 47)

"We thus visualize *Archimedes* as a consortium of *Fenestella* and of a protean alga. The algal symbiont in some cases started to grow upon the edges of an adult *Fenestella* zoarium, where the originally free-swimming flagellate zoospores could have attached themselves; in other cases, the alga started to grow from the base of a young *Fenestella* or from substratum near it, and the two coalesced. When growing independently the alga grew as a pillar or a whip, or as groups of the same, but whenever it started clinging to the *Fenestella* colony, it spread out against its branches, and, as it entered the fenestrules, enveloped the portion of the bryozoan meshwork completely. As the marginal bryozoan polypides next to the algal growth began to gemmate with renewed vigor either to right or left, from the area encrusted by the alga, the food-carrying current became deflected and started a vortex. Under the force of this current the growing bryozoan meshwork, centrally encrusted by the algal filaments began to coil. As the vortex or whirlpool became stabilized the bryozoan algal combination grew into a regular growth-form, a helicoid, with a standardized thickness of shaft, shape of flange, and length of pitch or height of volutions. Because both the Bryozoa and the alga apparently shared in the control of the vortex, the various types of screw, which we recognize as species of *Archimedes*, resulted from the combination of the various species and varieties of the *Fenestella* and the encrusting alga.

"In most cases the screw and the coiled bryozoan frond grew to a more or less definite size characteristic of the species, apparently controlled by the combination of the characteristic symbionts and by the vigor and strength of the formed consortium. Ordinarily the algal symbiont was segregated into the shaft and flange and was apparently sending out only a thin veneer upon the bryozoan frond volutions. However, occasionally the algal tissue segregated at various points of the frond volution into pillar-like bodies or "supports" given off at right angles from the reverse, occasionally from the obverse, or at various, but more or less radial, directions from the edges of the volutions. In some cases the marginal segregation of the algal fibres resulted also in the production of adventitious screws."

This consortium hypothesis is a most interesting contribution, but one that, in the opinion of this reviewer, has a number of serious obstacles to hurdle before it can begin to receive serious consideration. The *a priori* conclusion that because the tissue of the frond differs in structure from that of the screw the two are of necessarily different organic origin is unsound; textural differences correlated with differences of function are the rule, rather than the exception, among the invertebrates as well as among other organisms. The fact that wood is of different textural character than a leaf does not require that they be considered a symbiotic consortium of two different types of organisms!

If the screw is formed of an algal growth, surely that alga existed independently of the bryozoa. Yet the strata that contain abundant remains of *Archimedes* do not contain any algal form of structure similar to that of the screw. The authors suggest that "precipitation of lime in *Archimedes* has probably been initiated by the bryozoan symbiont and extended to the intimately connected algal partner while the latter precipitated little or no lime by its metabolic activity." This would suggest that virtually any form of alga would have served in the consortium (the authors recognize three types of screw), since the *Fenestella* required only the presence of an alga to initiate the precipitation of calcareous material. If this be true, it is most difficult to understand the absence of *Archimedes*, other than the two non-characteristic *Helicopora*, from the Silurian and the Devonian strata, especially the latter, where *Fenestella* is almost as abundant as it is in the Mississippian. It cannot be argued that the alga was not present at that time, since bryozoa with supporting structures essentially similar, texturally, to those of the screw of *Archimedes* occur as far back as Middle Ordovician time, and must be considered as possible bryozoan-algal consortia if *Archimedes* was so formed.

Among the, perhaps more minor, problems yet to

be met is an explanation of the fact that the flagellate algal zoospores always came to rest precisely upon the edge of the slender *Fenestella* colony rather than upon the broad surface of the frond; yet there is no known example of the encrusting tissue starting to grow elsewhere than upon the edge. Further, it is difficult to conceive a mechanism whereby "the marginal bryozoan polypides, next to the algal growth" that the bryozoan itself had encased in calcareous material, would begin to "gemmate with renewed vigor either to right or left" to form a helicoid coil when already a part of a large, and calcareous, frond. And, lastly, it seems inconceivable that the individual polypides, even though working in complete unison, would be able to set up a vortex or whirlpool of sufficient magnitude to overcome the effects of the normal bottom currents and eddies, and still have power to cause significant results in the shape of the colony.

So far as the paleontologist is concerned, the main value of this monograph will lie in the detailed descriptions and excellent illustrations of all known species of *Archimedes* and associated *Fenestella* fronds. The concept of a bryozoan-algal consortium, though far from proved—(even if eventually proven, it will still require much proof that it is a symbiotic rather than a parasitic association)—will undoubtedly have a beneficial result in stimulating further examination and research on the structures of this greatly neglected group of animals.

H. E. VOKES

BIBLIOGRAPHIC AND FAUNAL INDEX OF PALEOZOIC PELMATOZOAN ECHINODERMS. *Geological Society of America Special Papers, Number 45.*

By R. S. Bassler and Margaret W. Moodey. The Geological Society of America, New York. $4.75 (paper). vi + 734 pp. 1943.

This is another in the growing list of bibliographic aids that have appeared during the past few years to lighten materially the burden of the working paleontologist. The volume includes an outline classification, giving family assignment of the various genera of the cystoids, blastoids, and crinoids; a faunal list of species by localities for the world; and a bibliographic index and locality list for all described genera and species, arranged alphabetically by genera in each class.

No closing date is indicated for the manuscript, and while it contains some names proposed as late as 1942, others proposed in 1941 and 1942 are lacking, and it seems quite certain that it is to be considered complete only up through 1940.

H. E. VOKES

THE DINOSAUR BOOK: *The Ruling Reptiles and Their Relatives. Man and Nature Publications, Handbook Number 14.*

By Edwin H. Colbert. Illustrated by John C. Germann. The American Museum of Natural History, New York. $2.50. 156 pp. 1945.

The anticipated pleasure with which one receives a book from the American Museum of Natural History turns to full satisfaction as you turn the pages of this book on the dinosaurs, their ancestors, and their relatives. Beautifully printed on the finest of paper, the very abundant half-tones and diagrams stand out in remarkable perfection. The graphic pictures of Charles R. Knight and other artists are supplemented by new illustrations prepared by John C. Germann, who excels in the design of clear and striking diagrams.

The book is also a delight to read. Clear, simple, and animated in style, a high school student will scan it with pleasure while at the same time professional biologists will find it both entertaining and instructive. From the introduction, with its dinosaur cartoons from *The New Yorker* and other magazines, to the index, which serves simultaneously as a glossary that gives the derivations of the scientific names, this is a superb achievement. The men who hunted the dinosaur fossils; the chief museums; the best references; the methods of hunting, collecting, and preparing fossils; the geologic ages; the evolution of the vertebrates to the dinosaurs; the therapsids; the birds; the pterosaurs and crocodiles, turtles and ophidians; ichthyosaurs, plesiosaurs, mosasaurs, and other sorts of sea serpents; and, of course, a vast concourse of dinosaurs themselves —all are here. Nor is the discussion limited to their structure. The descriptions of their adaptations and probable habits of life are most interesting, and naturally the problem of their extinction is not ignored. Tables of classification, geographic distribution, and geologic span are also included.

"One thing thou lackest . . ." There is no discussion of the "why" of evolution, even in briefest summary—no relation to that other side of the evolutionary picture which is of such consuming interest to the biologist of the present day, as it was to Darwin. This is all the more surprising in a book written by a colleague of G. G. Simpson.

BENTLEY GLASS

GENETICS AND CYTOLOGY

THE PRINCIPLES OF HEREDITY. *Third Edition.*

By Laurence H. Snyder. D. C. Heath and Company, Boston. $3.75. xvi + 450 pp. + 3 plates. 1946.

This standard text of genetics (2nd ed. reviewed Q.R.B. 15:365) has been considerably improved by the changes made for the third edition, although its fundamental character and choice of material remain the same. The chapters dealing with quantitative inheritance have been grouped, and the chapter on the statistical treatment of data has been rewritten to give

added emphasis to the standard deviation and standard error, and to deal briefly with the differentiation of genetic from non-genetic variation and with the estimation of the number of multiple factors involved in a quantitative difference. The diagrams of mitosis and meiosis have been modified in the light of present knowledge; four-strand crossing over is now discussed; and the biochemical mutation studies in *Neurospora* receive a page in the chapter on "How Genes Act." The principal changes are to be found in the chapters on human inheritance. Here the effort to catalog human genes has been replaced by a more effective representative treatment, with discussion of incomplete sex linkage, tentative chromosome maps, and gene frequency equilibria. The Rh factors and their relation to erythroblastosis and feeble-mindedness have been added to the chapter on multiple alleles, and to the chapter on eugenics some new material has also been added. Problems and references remain as in the second edition.

Whether used as text or accessory reference in the elementary course in genetics, the new edition is certain to enhance the general high regard in which *The Principles of Heredity* is already held. Because of the greater emphasis it gives to human heredity than is to be found in other standard texts, this one is the outstanding book for courses in genetics for pre-medical students. At the same time it provides a very fine general introduction to the subject for all classes of students.

BENTLEY GLASS

HEREDITY AND ITS VARIABILITY.

By T. D. Lysenko. Translated by Theodosius Dobzhansky. King's Crown Press, New York. 50 cents (paper). 65 pp. 1946.

Were it not for the exalted esteem in which Lysenko is held by Russian scientists and the political prestige he enjoys, this book would have to be dismissed as of no moment. In fact, it would never have been translated into English. Thanks to Dobzhansky, every biologist can now assess the scientific knowledge and acumen of Lysenko for himself. What is the verdict? One finds an astonishing revelation of a successful plant breeder who attacks Mendelian and particularly "Morganian" genetics with virtually no comprehension of what they really are. Lysenko's biology is a strange mixture of obvious and well-known facts which he states emphatically, as though sure the "Morganians" will disagree, and of the most grotesque misconceptions about modern genetics.

The core of Lysenko's biology is a Lamarckian belief in the inheritance of acquired characters. This is supported by a number of experiments, unfortunately not described adequately as to techniques, but certainly interesting and worth repeating to see whether they can be confirmed. These include the famous vernalization process and the even more remarkable vegetative hybrids, such as come from grafts of tomato varieties, or of a tomato scion on a nightshade stock. This procedure, according to Lysenko, results not only in the permanent transfer of hereditary properties of the stock to the scion, but is followed by segregation in later generations propagated by seed. Of course, Lysenko repudiates the possibility of any such "unintelligible, inexplicable phenomena" as chimaeras being responsible for this.

But there is nothing to be gained by a prolonged criticism. This book has to be read to be appreciated. Because of its profound unhappy influence upon the excellent research in genetics formerly existing in the U. S. S. R., and because of its symptomatic character, let us hope that no American biologist will fail to examine it.

BENTLEY GLASS

CHROMOSOME ATLAS OF CULTIVATED PLANTS.

By C. D. Darlington and E. K. Janaki Ammal. George Allen & Unwin, London (The Macmillan Company, New York). $2.75. 397 pp. 1945.

Besides attempting to compile a comprehensive list of chromosome numbers (which includes those of wild species as well as of their cultivated relatives), the authors of this "atlas" have included in their catalogue cultural and geographic information relevant to each species. Emphasis is thus placed on the evolution of the present-day forms, taking into consideration N. I. Vavilov's concept of "centers of diversity" as well as the role of variation in chromosome number.

The book, indeed, is dedicated to Vavilov, and the 28-page introduction (while it gives due credit to Vavilov's predecessors and, as might be expected, includes a characteristic contribution of Darlington's own), is a fitting tribute to the Russian biologist's work.

Although necessarily incomplete (it lists about 11,000 species, for some 1000 of which the chromosome number is unknown), this book will undoubtedly be added to from time to time, and will be an invaluable source of reference for workers in the fields of plant-breeding, taxonomy, and cytogenetics. The reader will doubtless notice that the maps on the front and back endpages have been reversed in relation to the references in the text.

EILEEN SUTTON GERSH

THE GOLGI APPARATUS—AN INTERPRETATION OF ITS STRUCTURE AND SIGNIFICANCE. *Annals of the New York Academy of Sciences, Volume XLVII, Article 1. By Leonard G. Worley. New York Academy of Sciences.* 75 cents (paper). Pp. 1–56 + 2 plates. 1946.

This review is limited largely to recent work on the Golgi apparatus. It differs from most earlier reviews in that it relies largely on observations of the structure in stained or unstained, living cells, many of them reported by the author himself. With this as a background, the author attempts to account for the artifacts of fixation. The interpretation of the composition and function of the Golgi apparatus is extraordinarily pliable, and is capable of absorbing the findings of the next generation of histophysiologists and cytochemists.

ISIDORE GERSH

GENERAL PHYSIOLOGY

PHYSICAL CHEMISTRY OF CELLS AND TISSUES.

By Rudolf Höber with the collaboration of David I. Hitchcock, J. B. Bateman, David R. Goddard, and Wallace O. Fenn. The Blakiston Company, Philadelphia and Toronto. $9.00. xiii + 676 pp. 1945.

When Höber told me—I think it was as far back as 1937—that he was being urged to bring out an English revised edition of his classical *Physikalische Chemie der Zelle und der Gewebe*, I must confess to having smiled to myself. I thought of Höber as a pillar of the 'Old School' of general physiologists to whom the swelling and shrinking of colloids was the clue to all cellular behavior; I had read Höber's two volumes again and again and had always been impressed with the coordinating power exhibited by its author which led to his building a magnificent structure from the numerous experimental data of general physiology; but, as the years went by and more and more bricks in the building were shown, by the more accurate quantatitive methods of later days, to be either rotten or misplaced, it seemed to me that the building must collapse and that it would require a workman trained in the newer school to set about the task of rebuilding. I was therefore pleasantly surprised to find that Höber had made the attempt; the result is an outstanding tribute to the amazing resilience of his mind, which has clearly kept abreast of, if it has not taken the lead in, the changing trends of thought in general physiology.

When *Das Physikalische Chemie der Zelle und der Gewebe* was written, the points of contact between pure physical chemistry and the somewhat crudely determined facts of biological activity were comparatively few, and the author was able to cover the necessary elementary physical chemistry adequately himself, consisting as it did largely of colloid chemistry and elementary thermodynamics. Today, however, what with the rapid development of quantitative methods in the study of biological activity and of more direct and refined methods of elucidating tissue and cell structure, such an elementary disquisition on the principles of physical chemistry would have been inadequate and Höber is to be congratulated on appreciating the importance of this point and on the choice of his collaborators. David I. Hitchcock has contributed an excellent series of chapters on diffusion, chemical kinetics, and elementary thermodynamics, with special reference to electromotive forces and the properties of solutions; J. B. Bateman has managed to describe, in the compass of 110 pages, all those aspects of surface chemistry, and of the behavior of large molecules generally, in which the biological workers can be interested; this, too, is an excellent section and could stand on its own feet as a valuable monograph, since I know of no other treatise on the subject so well packed with information useful to the biologist. David R. Goddard has made an extremely interesting and well connected story of the respiration of cells and tissues, a subject that can be so harassing to the general physiologist who knows that probably all of the phenomena he is studying from a purely physico-chemical point of view are intimately connected with cellular metabolic processes, and who yet gets hopelessly lost in a whirlpool of linked chemical reactions if he plunges lightheartedly into the original literature. This section of Goddard's contributes in no small measure to the value of the book, especially in so far as it must ever be a reminder to the physical chemist that, however simple a secretory process looks to him in terms of the migration of ions and molecules, the energy supplied to maintain this activity must be derived from a baffling system of intimately linked chemical reactions. Goddard is to be congratulated on the lucid unfolding of a complicated theme and Höber for his far-sightedness in incorporating a section of this sort in the book. Finally, Wallace O. Fenn has contributed a section on contractile tissues with special reference to muscle. Here again the reviewer can do nothing but praise; descriptions of muscular activity in the majority of texts are too often tiresome catalogues of the varied effects of stimulation under different conditions; Fenn has kept to the forefront the essential problem: 'What is the real structure of muscle and why does it contract?' We are carried smoothly through the question of the nature of the cross-striations, the birefringence and x-ray diffraction of muscle and myosin, the interpretation of length-tension diagrams, the heat production of muscle, and finally an excellent critical review of the current theories of the mechanism of muscular contraction. Fenn's style and lively criticism are particularly happy and make this section perhaps the most readable of the book, if such a remark can be made without invidiousness where all contributions are of so high an order.

These four sections comprise rather more than half the book, and the remainder, which covers the phenomena of permeability, biological potentials, narcotic action, salt action, intestinal absorption, urine forma-

tion, and secretory processes generally, is Höber's personal contribution. The section on permeability and the structure of the cell membrane is a lucid and straightforward description of the facts and, as such, is sufficient for the initiated reader; to the person whose interest is more general, perhaps a brief review of Danielli's attempt to reconcile the apparently antagonistic concepts of the lipoid and pore membranes would have produced a more intellectually satisfying picture. However, as Danielli's theory appeared in print in 1943 and the book was probably in press at the time, this is probably a carping criticism.

The chapters dealing with the effects of ions and non-electrolytes on muscle and nerve are exceedingly well balanced and well reasoned; one suspects that the author has not lost his partiality for the 'colloid-chemical viewpoint' but this has not prevented him from doing full justice to other possible interpretations of the phenomena he describes. The chapters dealing with the active transfer of solutes against concentration gradients, as manifested in a variety of ways—intestinal absorption, urine formation, osmotic regulation, and so on—are especially valuable since they emphasize the underlying unity in what appears, at first sight, to be a wide range of scattered phenomena.

Space prevents me from going into further details of Höber's personal contribution; the phenomena he covers are diverse and manifold, and his pages are a rich gold mine of facts and references interesting to the general physiologist. The English is at times awkward but rarely so as to impair one's comprehension of the argument and, when one considers that the author is not writing in his native language, the insignificance of the defect is a further tribute to his energy and skill.

In general, then, the *Physical Chemistry of Cells and Tissues* is a first class contribution to the literature of General Physiology—it is a credit to its parent, *Das Physikalische Chemie der Zelle und der Gewebe*, and will be to us, today, what Bayliss's *Principles of General Physiology* was to us yesterday. Höber as the architect and chief mason must be wholeheartedly praised, as also his collaborators, Hitchcock, Bateman, Goddard, and Fenn. It may well be said that the wisdom and benevolence exhibited by the University of Pennsylvania, when they offered Höber an intellectual home, have borne a rich harvest.

(The war years had severed my contacts with the U. S. A. and it came as a grievous shock to me to learn from the dedication of the book that Dr. Josephine Höber, whose name so frequently figured as a collaborator of Dr. Höber, had died before the completion of the book; anyone who knew the Höbers must appreciate what a blow this was and can only admire Dr. Höber's fortitude in pursuing his task to the, I hope, not too bitter end.)

HUGH DAVSON

PHYSICAL CHEMISTRY FOR PREMEDICAL STUDENTS. *International Chemical Series.*

By John Page Amsden. McGraw-Hill Book Company, New York and London. $3.50. ix + 298 pp. + 1 table. 1946.

This text was written for a one-semester course for premedical students and presumably includes only those portions of elementary physical chemistry which will be of value to such a student in his later professional work. The subjects covered include gases, liquids, solutions, properties of solutions (electrolytes and non-electrolytes), chemical equilibrium, hydronium ion, oxidation and reduction, speed of reaction, catalysis, adsorption and the colloidal state. Two important features of the book not found in similar texts are (1) a chapter devoted to dimensions and units and (2) a list of useful movies to be used for demonstrating principles discussed. The students will not find the text difficult to follow, due to the simplicity of its presentation. The mathematical requirements have been kept to a minimum. Numerous applications of the principles covered, as well as problems for the student, are included in each chapter.

Although the book has much to offer in its favor it is the opinion of the reviewer that it alone will not meet the needs of the premedical student as far as physical chemistry is concerned. The last three chapters, dealing with oxidation and reduction, speed of reaction, catalysis, adsorption and the colloidal state are clear but are far from complete even for an elementary understanding or application to medicine. Furthermore it seems unfortunate that certain phases of thermodynamics are not discussed. The kinetics of catalyzed reactions and the effect of temperature on the speed of reactions are covered in approximately one page. Certainly an understanding of the action of various drugs and their application to medicine requires an elementary knowledge of certain phases of thermodynamics. A discussion of such material as free energy, heat and entropy changes during chemical reactions and their application to biological energy transformations is greatly needed.

Amsden's text offers, therefore, an introduction to certain phases of physical chemistry, but even for premedical students outside reading will be necessary. In this respect it is unfortunate that a bibliography is not included to aid the student.

W. D. MCELROY

ANAEROBIOSIS IN INVERTEBRATES. *Number 4 of the "Biodynamica Monographs."*

By Theodor von Brand. Biodynamica, Normandy, Missouri. $4.80. 328 pp. 1946.

Those who are acquainted with the investigations concerning the anaerobic metabolism of the bacteria and

of vertebrate tissue will not be greatly impressed with the information available on the invertebrates. This is no criticism of von Brand's book on the anaerobic life of the invertebrates, but merely expresses the lack of work done on these forms. In *Anaerobiosis in Invertebrates* von Brand considers: I, The Occurrence of Anaerobiosis among the Invertebrates; II, The Anaerobic Metabolism of Invertebrates; III, General Adaptation to the Lack of Oxygen and Origin of Anaerobiosis.

In Part I such subjects as (1) methods of determining oxygen tension, (2) establishment of anaerobic conditions, (3) anaerobic habitats, and (4) a survey of invertebrates for anaerobiosis are considered.

In Part II consideration is given to (1) partial transition from aerobic to anaerobic metabolism, (2) aerobic fermentations, (3) the source of energy in anaerobiosis, (4) anaerobic processes, and (5) recovery from anaerobiosis. To many readers this section will be disappointing; for the titles of several chapters would lead one to suspect a discussion of such things as enzymes, phosphorylation, etc. The latter topic is mentioned once in passing and does not occur in the index. Even though relatively little information is available concerning the intermediary metabolism of the invertebrates, such information as is available should be critically analysed in the light of our present-day knowledge of metabolism in bacteria and vertebrate tissue. For example, to conclude that lactic acid production is unrelated to the production of succinic acid because in phosphate buffer lactic acid predominates, while in bicarbonate media succinic acid is more abundantly formed, is not justified. A reasonable interpretation would be that the production of the two acids is closely related and that a change of carbon dioxide tension would alter the proportions, i.e., initial reduction of pyruvate to lactic or initial fixation of CO_2 onto pyruvate, with subsequent reduction to succinic acid.

Readers who are not familiar with the bacterial and vertebrate tissue metabolism may be misled by statements such as: "It seems well established that, during the recovery of frog muscle from anaerobiosis, $\frac{1}{4}$ of the accumulated lactic acid is oxidized to CO_2 and H_2O, and that the energy liberated thereby is used to resynthesize the remaining $\frac{3}{4}$ to glycogen." This is partially true when considering the over-all fate of the carbon atoms but is misleading when a mechanism is being considered. Experiments on oxidation assimilation indicate that partial oxidation and decarboxylation of all the lactate molecules occur, with the resulting intermediate ultimately entering into the formation of glycogen. There are other instances where comparison to analogous situations in the bacteria would have been profitable.

In Part III such problems as (1) the origin of anaerobiosis in invertebrates, (2) the basis for the differences in anaerobic functions among invertebrates, (3) the place of anaerobic processes in the general metabolism of invertebrates, and (5) anaerobiosis and the origin of endoparasitism are considered.

The book is well bound and printed on excellent paper. There are over 1,000 references to the original literature and an author and subject index. A short appendix lists the fauna occurring in various anaerobic habitats. The book will be of value to those who are interested in the habitats in which invertebrates may live and will present many problems to those who are interested in comparative biochemistry.

W. D. McElroy

GENERAL AND SYSTEMATIC BOTANY

Plant Life of the Pacific World. *The Pacific World Series.*

By Elmer D. Merrill. The Macmillan Company, New York. $3.50. xv + 295 pp.; 1 map. 1945.

In order fully to appreciate the magnitude of the task accomplished by E. D. Merrill in his little book on Pacific botany, it is almost necessary for the reader to have experienced the bewilderment of a northern traveler when he first sees the vegetation of the tropics. The feeling is one of hopeless frustration, for the landscape is clothed with hundreds or thousands of species, not one of which is recognizable. Even the forms of plants are bizarre, and size is gauged to an unfamiliar scale. During the war this experience was vastly magnified when we moved great masses of men to the southwestern Pacific. Not only did they themselves see the tropics, but they have brought home and disseminated their impressions of the strange landscapes they saw. *Plant Life of the Pacific World* was first published for use by men in the armed services, and is now available in somewhat different format for broader consumption. With almost uncanny clarity and simplicity it reduces to order the seemingly impenetrable tangle of fact and fancy that pervades the novice's impressions of tropical vegetation.

The book is not a technical manual of Pacific botany, yet it contains an astonishing amount of specific, authentic botanical information. These technical data are never "paraded," but are slipped into the text in such a way as to make them easily available though innocuous. Above all, the book is *readable* even for laymen whose foreknowledge of natural history is at a minimum. It has the further quality that it need not be read consecutively, but may be opened at random and read in parts that are brief and more or less self-contained. The author has hit upon the clever device of organizing his material in numerous short sections placed under subject headings that are quickly recognized. In the chapter on The Primary Forest, for instance, there are the following items: Effect of populations on forested areas; Characters of the forest;

Ground-cover; Relative paucity of animal life; The primary forest as an organism; The struggle for existence among plants; Memories; A tropical storm; Tropical *versus* temperate-zone forests; Buttressed trunks; Paucity of conspicuous flowers; Some characteristic genera; The Dipterocarp forests; Eucalyptus forests; Specific endemism in primary forests; Evergreen *versus* deciduous forests; The mid-mountain forests; The mossy forests; The elfin-wood; Temperate-zone elements; Regions of special botanical interest; False first impressions; Cyclic flowering; Redundance of vegetation; Differences in tropical and temperate-zone species.

The book begins with a review of the "witch-tales" of tropical botany contrasted with the hazards that actually exist. The title of the first chapter, The Safe Forests and Jungles of the Tropics, indicates the author's attitude toward these hazards. There follows a chapter on general principles of botanical classification—a subject that can be dry and abstruse, but is here kept well within the bounds of readability. Then come chapters on various types of vegetation, tropical weeds, cultivated plants, jungle foods, and plant geography. Finally there are notes on local plant names, the botanical characteristics of specific island groups, history, exploration and bibliography, and directions for collecting specimens. The book closes with a systematic list of the species discussed, a glossary, and a general index. Illustrations are numerous and well-executed line drawings, to the number of 256, with a general map of the western Pacific on the front end papers.

Particular attention should be called to the chapters on geographic botany. Merrill speaks with authority on the complex problems of distribution in the Far East, outlining existing knowledge and theory, and pointing out major fields for future investigation.

HUGH M. RAUP

HAWAIIAN FLOWERS.

By Loraine E. Kuck and Richard C. Tongg. Illustrated by Ted Mundorff. Tongg Publishing Company, Honolulu. $3.50. 109 pp. + 16 plates. 1943.

Hawaiian Flowers contains popular descriptions of about 125 plants, most of them illustrated in sixteen beautifully colored plates. Each plate includes from seven to ten species, with a small replica at the bottom of the page upon which the different species are numbered for reference to the legend. The printed descriptions are brief, and usually contain notes on habitat, frequency, and native significance. A particularly useful section of the book is found in the Introduction, where some "floral itineraries" are given for the vicinity of Honolulu.

HUGH M. RAUP

PLANTS OF HAWAII NATIONAL PARK ILLUSTRATIVE OF PLANTS AND CUSTOMS OF THE SOUTH SEAS.

By Otto Degener. Published by the author, New York Botanical Garden, Bronx Park, New York. $2.50 (paper). xv + 314 pp.; 1 map. 1945.

This book is a photo-lithoprint edition of Degener's *Illustrated guide to the more common or noteworthy ferns and flowering plants of Hawaii National Park, etc.*, which appeared in 1930. It begins with a brief summary of existing knowledge concerning the geologic history of the Hawaiian Islands, together with some notes on the geographic origins of the present flora. The main body of the text is given over to discussions of plants which have long been in use for one purpose or another by the native peoples. It is not a manual, but rather a series of illustrated essays arranged in the systematic sequence of a floristic work. These essays are informative, clear, delightfully written, and not without humor.

Descriptions of the various plants mentioned follow a fairly uniform pattern, but the presentation is never abbreviated as it is in most floristic books. First are given the essential facts about the plant's name, its family relationships, and its distribution, both general and local. Then comes a rather complete description of the plant itself, usually illustrated with an excellent line drawing. Finally the native uses of the plant are described, and it is here that the rich lore accumulated by Degener throughout his many years in the South Seas is told with sympathy and keen understanding.

In addition to the line drawings, which appear as plates, there are numerous text-figures, many of which are photographs. The latter have lost some clarity in the photo-lithoprinting, but they are still good. The book is also supplied with a combined index and glossary.

HUGH M. RAUP

HISTORIC FOUNDATIONS OF BOTANY IN FLORIDA (AND AMERICA).

By William Alphonso Murrill. Published by the author, Gainesville, Florida. $2.00 (paper). 51 pp. 1945.

TREES.

By William Alphonso Murrill. Published by the author, Gainesville, Florida. $2.00 (paper). 65 pp. 1945.

A GUIDE TO FLORIDA PLANTS.

By William Alphonso Murrill. Published by the author, Gainesville, Florida. $2.00 (paper). vii + 89 pp. 1945.

William Alphonso Murrill is one of the "elder statesmen" of American botany. His primary work has been in the fungi, but his interests in natural history are extraordinarily broad. I have grouped these

three papers for review because they appear to summarize many of his lifelong "extra-curricular" observations. There is much of reminiscence, of people and places, in all of them; and they will undoubtedly prove useful to botanical historians as well as to naturalists whose concern is with the observations themselves. Furthermore, though there is a great deal in them of general interest, their central theme is the botany of Florida.

In *Historic Foundations of Botany in Florida (and America)*, there is first a brief review of Florida geology and paleobotany, with general geographic and historical notes on that state. Most of the book is devoted to short accounts of the life and work of American botanists, and of European students whose labors brought them to America. The author has attempted to organize part of his material into "early" and "modern" groups, and part of it by subject matter. It would be more readily usable, perhaps, if all of it had been arranged chronologically. A chapter on "Botanical education in Florida" should prove of value to all naturalists interested in the opportunities for botanical research there.

Trees contains a series of essays on common species in the southeastern United States. The author has long been concerned with problems of shade tree selection, planting, and preservation, particularly in cities. These essays bring together a mine of information drawn from his many years of study. The book should be of value to landscape architects and municipal planning organizations throughout the south. One chapter is devoted to the trees of Florida, with keys to the hollies and oaks of the Gainesville area. Diseases of trees are the subject of two chapters, wherein are given indices to leaf fungi, Florida rust fungi, and hosts. The book closes with a selected bibliography.

A Guide to Florida Plants begins with some essays on forests, botanical history, fossil plants, and trees as media for the teaching of botany to children. Most of the book is made up of lists, keys, and brief discussions of Florida plants, including mosses, liverworts, fungi, and seaweeds. It is concerned principally with the vicinity of Gainesville, with chapters on woody vines, spring wild flowers (woody plants), summer flowers, insectivorous plants and orchids, and composites. There are keys to Florida goldenrods, blazing stars, asters, and erigerons.

HUGH M. RAUP

GUIDE TO SOUTHERN TREES. *Whittlesey House Field Guide Series.*

By Ellwood S. Harrar and J. George Harrar. Whittlesey House, McGraw-Hill Book Company, New York and London. $4.50. ix + 712 pp. 1946.

This little book, in handy pocket size, is third in the series of Whittlesey House Field Guides. It deals with more than 350 species of trees native in the region bounded on the north by the Mason and Dixon line, the Ohio River, and the Missouri-Arkansas boundary. Its western limits are those of the forest itself. The book is illustrated with 201 plates containing excellent line drawings, and with several text figures in the Introduction. The plates show sketches of twigs in both summer and winter condition, and details of flowers, fruits, buds, and leaf scars.

The first forty-four pages are devoted to an Introduction in which are given some notes on classification, nomenclature, and the gross morphology of trees. The sections on the diagnostic characters of leaves, flowers, inflorescences, fruits, twigs, and bark are well written and illustrated. Bark, as the authors state, is difficult to describe in words, but a few half-tone illustrations would add greatly to this part of their treatment. The Introduction closes with a key to genera and a few species. Keys to most of the species are interpolated in their appropriate places farther on in the text.

Descriptions of individual species are given in considerable detail, with their material well organized and the items set off by headings in boldfaced type. In addition to notes on habit and structural characteristics there is essential information on habitat, general geographic distribution, and economic significance. Finally at the end of the book are a glossary, a list of selected references, and a general index. The work as a whole will be useful not only for students and amateur botanists in the south and for casual travelers, but also for beginning students in more northern areas who find it necessary to determine specimens of trees from the southeastern United States.

HUGH M. RAUP

AMERICAN SPECIES OF AMELANCHIER. *Illinois Biological Monographs, Volume XX, Number 2.*

By George Neville Jones. The University of Illinois Press, Urbana. $2.00 (cloth); $1.50 (paper). 126 pp. 1946.

American Species of Amelanchier is a monographic study of the taxonomy and geography of the genus as it is represented in North America. Two species formerly placed in *Amelanchier* but now referred to the genus *Malacomeles* occur in Guatemala, Mexico, and southern Texas. They are relegated to another paper. Following a short Introduction, in which the author deals with the history and general problems of the classification of *Amelanchier*, there are keys and descriptions for the eighteen species recognized. Separate keys are given for flowering and fruiting specimens. Under each species there is a discussion of its nomenclature and taxonomic position, with citation of specimens, synonymy, type locality, and general range. Spot maps show the distribution of most of the species.

The paper closes with a list of the numbered exsiccatae cited, and an index to names. There are 23 half-tone plates of types and authentic specimens.

In making his study of *Amelanchier*, Jones has had access to collections in most of the larger herbaria in this country. He has also had considerable field experience both in the east and in the west. It is probably safe to say, however, that no one, Jones least of all, will follow this monograph in its entirety as the last word on the genus. The species are notoriously variable in habit and in leaf form and serration. The seasonal variation in appearance within the same species is so great that one often is tempted to describe a single stage of development as a new entity, if the whole series is not at hand. Much of the taxonomic difficulty with the genus has been ascribed to hybridity, but Jones follows Wiegand in thinking that natural hybrids are not common enough to account for more than a fraction of it. He thinks that a more reasonable explanation, based upon such cytological studies as have been made, is that *Amelanchier*, a member of the subfamily Pomoideae, partakes of the variability which appears to be correlated with the complex polyploidy in that subfamily. In any case, the genus is, and probably will continue to be, a difficult one. Whether or not we wish to agree with all of Jones' delineations of species, his work will be extremely useful.

HUGH M. RAUP

BIBLIOGRAPHIE DES TRAVAUX CONCERNANT LA FLORE CANADIENNE, PARUS DANS "RHODORA", DE 1899 À 1943 INCLUSIVEMENT, *Précédée d'un Index Alphabétique de Tous les Noms Botaniques Nouveaux Proposés dans Cette Revue. Contributions de l'Institut Botanique de l'Université de Montréal, No. 54.*

By Ernest Rouleau. Institut Botanique, Université de Montréal, Montréal. $2.00 (paper). 368 pp. 1944.

Rhodora, the monthly journal published by the New England Botanical Club, is now in its 48th volume, and has become nearly indispensable to students of boreal and temperate American floras. Since the first printing of the seventh edition of Gray's *Manual* in 1908 this periodical has been the principal medium for the publication of critical studies which, taken together, have done most toward keeping the *Manual* up to date. During this period, also, the field operations of Harvard botanists, notably M. L. Fernald, have been pushed into the Maritime Provinces and Quebec, so that their work has contributed extensively to knowledge of the Canadian flora. At the same time revisions of many groups of species published in *Rhodora* have been significant for all of Canada and Alaska.

Unfortunately, no cumulative index to this journal has ever been prepared, so that the task of finding references to particular species or groups of species has become difficult for anyone not already versed in the intricate literature of temperate and boreal American plants. Several years ago the French botanists at the University of Montreal, fully realizing this condition and conscious of the values for Canadian botany to be found in *Rhodora*, undertook to publish indices of all items pertaining to Canadian plants. The first work, done by Jacques Rousseau, was printed serially in *Le Naturaliste Canadien*, and was entitled "Essai du bibliographie botanique canadienne. I. Les travaux contenus dans Rhodora: vol. 1 (1899) à 34 (1932)." It was later issued as a reprint but was soon exhausted. We now have the present revised and greatly enlarged index by Ernest Rouleau, bringing the coverage through vol. 45 of *Rhodora* and making a highly significant contribution to the general usefulness of the journal. It should be acquired by all institutions and individuals whose files of *Rhodora* are commonly in use by students and research workers.

Rouleau's index is in three parts. First is an alphabetical list of all new botanical names proposed in *Rhodora*, regardless of their geographic position. Second, there is a complete bibliography of all articles which deal directly or indirectly with the floras of Canada, Newfoundland, Saint-Pierre et Miquelon, Greenland, Labrador, and Alaska. This bibliography is arranged alphabetically by authors' names and contains, in addition to publication data, alphabetical lists of all species mentioned in each article. Finally, the third part consists of an index to all genera, species, varieties, and forms contained in the second

HUGH M. RAUP

ECONOMIC BOTANY

THE HERBAL OF RUFINUS.

Edited from the Unique Manuscript, by Lynn Thorndike, assisted by Francis S. Benjamin, Jr. University of Chicago Press, Chicago. $5.00. xliii + 476 pp. 1945.

In publishing the *Herbal of Rufinus*, Lynn Thorndike has made available to the student of the history of botany and pharmacognosy a rare and hitherto little known herbal of the Middle Ages. The herbal, which once was in the possession of Lord Ashburnham, is now in the Laurentian Library of Florence, where it is listed as Ms. Ashburnham 189. The title page is captioned as follows: "*Rufinus de Virtutibus Herbarum.* Incipit liber de virtutibus erbarum et de compositionibus earum compillatus per summum doctorem Magistrum Rufinum de dictis summorum phylosophorum Diascoridis, Circa instantis, Macri, Alexandri, Salerni et Ysaac et quamplurium aliorum doctorum." The Laurentian manuscript is a handsome illuminated folio comprising 118 double-columned leaves. The

text, in Latin, is believed to have been written during the last quarter of the thirteenth century. During the succeeding centuries Rufinus' work appears to have been mentioned only by Benedetto Rinio, a fifteenth century herbalist of northern Italy.

Concerning the author of the herbal comparatively little is known. In the preface he tells us that he had pursued the seven liberal arts in the cities of Naples and Bologna and that after studying astronomy and astrology he turned to the science concerning herbs. We also know that he studied and taught astrology at Bologna. In the text he is spoken of as a monk and as "brother Rufinus penitentiary of the lord archbishop of Genoa" and it is said that he was considered a holy doctor as well as a master in the subject matter of the text. His manuscript bears witness to his extensive knowledge of the appearance and properties of plants of the environs of Naples, Genoa, Bologna, and Florence and to his familiarity with vernacular plant names of other parts of Italy.

In compiling his herbal Rufinus first selected, from earlier texts known to him, data on medicinal plants and materia medica, and then added his own observations on plants as he knew them in field, valley, and woods. In his preface he states, "I shall collect from the sages describing the virtues of herbs and their workings in inferior bodies according to what they experienced and the truth that they were able to discover concerning these. And first, I shall quote the words of Dioscorides; second, *Circa instans*; third Macer; fourth, Alexander, the philosopher; fifth, the masters of Salerno; sixth, Isaac; seventh, synonyms." About four-fifths of the text of Rufinus is given to quotations from these authors; but his own botanical descriptions and enumerations of the medicinal virtues of plants are by far the most important part of the text. He also frequently gives a comparison of different varieties of plants and related flora, many of which are neither found in other texts of the period nor are mentioned even by the great herbalists of the sixteenth century. Rufinus arranged his subject matter alphabetically in a double-columned page, each page divided into chapters of varying length and each normally dealing with a single herb or medicament. His quotations and bibliographical references are cited, followed by his own observations and notations, to which his signature is usually affixed. In reproducing the text in print the double-columned page has been omitted but the main sections are shown by spacing; the name of the herb or medicament is set in bold face type; and the titles of the references quoted are italicized for the clarity of the text and the convenience of the translator.

In tracing the editions of the various bibliographical sources referred to by Rufinus, Thorndike has pointed out in his introduction that the editions cited by Rufinus, especially those of Dioscorides and *Circa instans*, differ from those known today, indicating that there existed other versions of these early works which are probably not now extant.

The list of diseases, symptoms, and physical ailments referred to by Rufinus does not differ essentially from other European herbals. To the same herbal remedy are frequently attributed curative properties for widely diverse ailments. Approximately one-fifth of the remedies is devoted to the use of animals and their products, to minerals and compound medicines. Here again the text of Rufinus simulates other early herbals.

The first thirty-one pages of the text of Rufinus are occupied by a table of contents listing the herbs and medicines treated in the subsequent text. Under each simple are listed its effects. In editing the manuscript Thorndike has added five additional indices which greatly facilitate the research student in this field. The first gives a list of herbs, other simples, and some compound medicines; the second deals with diseases and parts of the body affected by them, and the third gives an index of measures, instruments, and utensils. The fourth and fifth list names of persons, titles of text, and names of places referred to by Rufinus. These latter are especially of considerable aid to the student of manuscripts of this period.

To the bibliophile as well as the student of botanical literature the value of this unique herbal lies not only in its extensive compendium of information gleaned from various early herbalists but principally from the extent of Rufinus' own contributions to the knowledge of the nomenclature, morphology, and medical usage of plants.

E. W. EMMART

THE WHEATS OF CLASSICAL ANTIQUITY. *The Johns Hopkins University Studies in Historical and Political Science, Series LXII, Number 3.*

By Naum Jasny. The Johns Hopkins Press, Baltimore. $1.75 (paper). 176 pp.; 2 plates. 1944.

The wheats grown in the Mediterranean lands during classical antiquity have had considerable study in the past. Utilizing these earlier studies, and combining them with reexamination of the documents referring to grain use, with recent advances in the botanical knowledge of wheat, and with his own expert knowledge of wheat from the practical agronomist's point of view, Jasny has restated the probable types of wheats used and their relative importance. Such a study is extremely difficult. Material is scanty. Archeologic material is quite limited, and is often not conclusive as to variety. The literature is also extremely difficult to use because the ancients did not classify by our modern methods. They most frequently described their wheats in terms of their growth habits and in terms of their uses, e.g., for bread, groats, fine white flour, etc. However, Jasny was able to make unusual use of such

information. His insight into milling methods, the characteristics of flour from various wheats, the losses in milling, etc., as well as his close knowledge of the growth habits of the various varieties of wheat and the new divisions of wheat based on genetic knowledge, made it possible for him to squeeze a great deal of meaning out of what at first sight seems scanty and unsatisfactory material.

The type of the material made necessary much involved discussion. At times Jasny was forced to draw conclusions from fairly slender evidence, and then to use these conclusions to proceed to further inferences. The method is unavoidable, and the author does not try to conceal what he is doing. The total result of this work is a considerable revision of previous thought about the types of wheat and their use in the Mediterranean. It is a work that should interest historians, plant geographers, botanists and agronomists, and many others.

GEORGE F. CARTER

TREES AND FORESTS OF LOUISIANA. *University Science Series.*

By Ralph W. Hayes, with drawings by Lillie S. Hoisington. Bureau of Educational Materials, Statistics, and Research, Louisiana State University, Baton Rouge. 15 cents (paper). 97 pp. 1945.

This is a small booklet produced jointly by the State Department of Education and Louisiana State University. The author is head of the Forestry Department in the University. The book is written for primary and secondary school children, and is designed as a sort of supplementary textbook urging the proper use and conservation of Louisiana forests. It has chapters on the structure and living processes of trees, the present condition of the state's forests, and problems of protection. A few of the commonest trees are described, each with a line drawing. A chapter called "The Story of Two Families" relates the history and results of good and poor land management, indicating that farm forestry is profitable in the long run. This would be a little more convincing if better documented as to geographic position, soils, relation to markets, etc. Besides the line drawings noted above, the book has several half-tone photographs and two maps, one of forest types in Louisiana, and the other showing the locations of national forests, state protected areas, and fire towers.

HUGH M. RAUP

FUNGICIDES AND THEIR ACTION. *Annales Cryptogamici et Phytopathologici, Volume II.*

By James G. Horsfall. Foreword by David Fairchild. Chronica Botanica Company, Waltham, Massachusetts; G. E. Stechert and Company, New York. $5.00. xv + 239 pp. 1945.

To persons who have not followed closely in recent years the development of the science of phytopathology, Horsfall's book on fungicides will prove a distinct "shocker." Not because of the language in which it is written (although it must be conceded that at times this may be a contributory factor), but because, unknown to the ordinary botanist, a high degree of precision, skill, and sound fundamental knowledge is now characteristic of what was once derisively termed "squirt gun botany." Few will deny the author's preeminence in the field of fungicides, and phytopathologists are indeed fortunate in having this up to date summary of the subject.

The book, fittingly dedicated to a great teacher of phytopathology, Herbert H. Whetzel, bears a short foreword by David Fairchild, recalling the pioneering days in the use of fungicides, in which he played an important role. After a short preface in which the aims of the volume are variously stated, the best, possibly, being that it "... attempts to develop the underlying theory on which the practice is based, and by which the practice may be improved," there is a chapter reviewing the history of the use of fungicides from Pliny's time to the present.

The main body of the text consists of chapters on such aspects of the subject as the objectives and methods of laboratory assay, problems of data assessment, fundamental principles of chemical protection, problems of deposition of the fungicide on the surface, and methods of obtaining and measuring the coverage of single and multiple surfaces. There are also comprehensive discussions of tenacity, artificial immunization and chemotherapy, as well as the fungicidal action of copper, sulfur, organic nitrogen compounds, and other organic compounds. Sections follow on antagonism and synergism, and on phytotoxicity. A bibliography of over 500 titles, a general index and author index conclude the book.

Although only one thoroughly familiar with this highly specialized phase of phytopathology can critically evaluate the contents of this book, it is evident that a large amount of material dealing with modern investigations on fungicides and their action has been brought together in excellent, careful fashion. In no sense, as the author rightly points out, is it a "cook book" for the practical man wanting aid on methods of creosoting railroad ties or of battling apple scab and potato blight. For the beginning investigator who has now, as have his older colleagues, grown up with the science, it should prove extraordinarily useful.

The few faults that have impressed this reviewer are not ones of content or organization, but rather of editing and bookmaking. A lack of editorial grip on the quite obviously enthusiastic and ebullient author has resulted in some instances in distracting interventions of personality between the contents and the

reader. Better editing would also have eliminated such statements as ". . . the vine-fretter (whatever that is)," since a quick look at any unabridged dictionary would have enlightened both author and editor.

The heavy, Teutonic "Handbuch" style of the front matter offers a formidable barrier to the reader's attempts to reach the body of the text. Thus, in order to get to the Preface, we first read a biography of the author, then turn to a relatively empty title page presumably for "Annales Cryptogamica et Phytopathologici" of which *Fungicides and their Action* is volume two. There then follows an elaborate title page for the series (in Latin, English, and Dutch) in best "Handbuch" tradition, which is succeeded by the title page of the book on fungicides, ornamented with a line drawing of a liverwort. Following this there is a copyright page which also includes information on the whereabouts of what are presumed to be some twenty agents of the publisher located in various parts of both hemispheres. The next (right hand) page bears a short English quotation from the early French phytopathologist Prévost. We then turn to a page devoted to advertising the various publishing enterprises of the Chronica Botanica Co. Finally, feeling much like a person who has traversed a cluttered entry way and reception hall to reach a splendid parlor, or, perhaps, like a movie fan who has impatiently endured the local advertising shorts, we at least reach the main feature.

F. K. SPARROW

GENERAL AND SYSTEMATIC ZOOLOGY

THE LIFE OF THE QUEEN BEE.

By Louis Sutherland. Bernard Ackerman, The Beechhurst Press, New York. $2.50. 126 pp. + 24 plates. 1946.

This is a fairly straightforward account of the yearly cycle of activities of the beehive, suitable for 'teenagers. Its factual content is about the same as that of Maeterlinck's *Life of the Bee*, but it avoids the philosophical discursions in which Maeterlinck revelled. Only occasionally does it slip into expressions of anthropomorphism or sentimentality. Some reference to the work and conclusions of von Frisch on the behavior of the worker-bee might have been included; but, as it stands, the book presents the outstanding features of the queen's and the hive's history acceptably. Its value is enhanced by some good photographs.

EILEEN SUTTON GERSH

THE FRESH-WATER FISHES OF SIAM, OR THAILAND. *United States National Museum Bulletin 188.*

By Hugh M. Smith. United States Government Printing Office, Washington. $1.50 (paper). xi + 622 pp. + 9 plates. 1945.

A DESCRIPTIVE CATALOG OF THE SHORE FISHES OF PERU. *United States National Museum Bulletin 189.*

By Samuel F. Hildebrand. United States Government Printing Office, Washington. $1.25 (paper). xi + 530 pp. 1946.

These two fine monographs are noteworthy additions to ichthyological literature, but as far as the general biologist is concerned, little more can be said than that they are detailed reports in the best tradition. This is especially true of the late Hugh M. Smith's monograph, which includes many interesting facts about the natural history and culinary uses of fishes in Thailand. It was probably not Smith's fault that his monograph lacks a map, an especially unhappy omission for a region unfamiliar to most biologists. Hildebrand's paper is provided with an adequate map.

JOEL W. HEDGPETH

HAWAIIAN FISHES. *A Handbook of the Fishes Found Among the Islands of the Central Pacific Ocean.*

By Spencer Wilkie Tinker. Tongg Publishing Company, Honolulu. $3.50. 404 pp.; 8 plates. 1944.

FISHES AND SHELLS OF THE PACIFIC WORLD. *The Pacific World Series.*

By John T. Nichols and Paul Bartsch. The Macmillan Company, New York. $2.50. 201 pp.; 16 plates. 1945.

These books are examples of the recent flood of popular guides inspired by the need for natural history information during the war in the Pacific. As popular guides assembled in haste, they suffer from many of the faults of such works and enjoy but few of their virtues.

Tinker's handbook is an entirely secondary work, compiled principally from the various systematic reports by Jordan and Evermann and Gilbert, and the bulk of the figures are copies from the old Bureau of Fisheries monographs. There has been considerable loss of detail in redrawing these figures, and it would have been better to make new cuts from the originals directly. In addition, there are eight color plates, displaying the more spectacular fish. Several forms, often of widely disparate sizes, are on each plate without indication of scale, and the reproduction is poor. Little consideration is given by the author to the relative abundance or importance of the fishes, and as much space is given to a fish known from a single specimen as to a commercially important food fish. In short, this "handbook" is an abridged summary of the older monographs.

Fishes and Shells of the Pacific World is a more successful book, considered from the standpoint of its intentions, although both fishes and shells deserve volumes to themselves. This dual treatment inevi-

tably results in incompleteness, and the most conspicuous omission is that of a bibliography for the fish part, although there is an adequate one for the molluscs. Neither part of the book is in any sense a handbook, but remains simply a description of the more conspicuous aspects of the fauna; they are therefore more suitable for armchair reading at home than as guides for travellers in the Pacific. An especially objectionable feature of the section on shells, from any standpoint, is the gathering of plates at the back of the book and the further segregation of the captions. There is no reason for the separation of plates and captions, especially since there is adequate space for each caption below the appropriate plate.

Both of these books demonstrate the difficulty of the task they were intended to accomplish, and for that reason many of their faults may be forgiven. That by Nichols and Bartsch is at least a fair beginning, and has the further merit of being interestingly written.

JOEL W. HEDGPETH

HANDBOOK OF LIZARDS: *Lizards of the United States and of Canada. Handbooks of American Natural History, Volume VI.* *By Hobart M. Smith. Comstock Publishing Company, Ithaca, New York.* $5.75. xxi + 557 pp. 1946.

It is rather novel to be able to incorporate into a book review the evaluations of a fair number of informed persons. This book became available shortly before the meetings of the Herpetological Society in Pittsburgh and was an object for comment by many of those present. Everyone with whom I spoke about it enthusiastically endorsed the *Handbook of Lizards* and considered it a well-done piece of work that was certain to be widely useful.

This sixth volume in the series of Handbooks of American Natural History follows earlier volumes concerned with frogs and toads, mammals, salamanders, aquatic plants, and mosquitoes. The present book is divided into two parts, an Introduction, and the Accounts of Species. The sixty-page Introduction is a big step towards the still unwritten "Biology of Reptiles," including sections on the zoological position of lizards, their characteristics, distribution, major groups, fossil history, morphology, habitats, life history, habits, folklore, economic importance, captivity, collection, preservation, American saurologists, and other problems. Obviously Smith could not treat all these topics in detail; among the more interesting and extensive may be mentioned those concerned with the eye, tail, temperature regulation, color change, and protective reactions.

The Accounts of Species begin with a key to the families; at the beginning of each family section there are generic keys; whenever necessary there are specific keys. The keys are accompanied by line drawings which were assembled specifically to illustrate characters described in the keys. Each species, of which there are 136 in the United States and Canada, is discussed under several headings, usually as follows: range, size, color, scalation, habitat, habits, recognition characters, comparisons, problems for future study, and references. Practically every form is illustrated with several photographs, largely the work of A. H. Wright.

Following the accounts of species, there are 30 pages of distribution maps designed to illustrate the ranges of the various races of lizards as Smith understands them. An interesting map shows the number of forms known from each state. California, Arizona, Texas, and New Mexico (in that order) lead the remainder of the states in the number of races of lizards; each has 38 or more forms while the rest of the states each have fewer than 25. Maine, Vermont, New Hampshire, and Rhode Island appear to be without lizards.

After the maps there is a list of general literature and then a list by states. For each state there are given all the species known from the state and a series of pertinent references. There follows a list of literature cited in the main body of the text. The book is concluded with a twelve-page index.

Prior to the appearance of this volume there was no single comprehensive work on American lizards; on the other hand there are several good books on snakes. The need for a lizard handbook has been filled in a most successful manner by Smith's handbook. The text is very readable, very informative, and, as far as I am able to judge, very accurate. The line drawings have been selected with a view to their usefulness, and the distribution maps (of the Ben Day type) are fine examples of clarity. The state lists are certain to interest local amateur naturalists, and the introduction is bound to be of value to professional biologists even though they are not particularly interested in lizards. To herpetologists, of course, this excellent book will be a necessity.

It would appear necessary to append some points of difference, even if they are relatively minor. Several names not currently used (e.g., *Gambelia* for part of *Crotaphytus*, *hyacinthinus* for *fasciatus*) are recognized here; I should prefer separate prior publication of nomenclatorial changes rather than to have them introduced in a handbook. Over thirty such cases are involved. Although many of the photographs are excellent, a number of plates offend the eye. In an effort to conserve space many photographs are crowded together in one plate, in a jig-saw fashion; since the backgrounds of most of the half-tones are of unequal values the plates come to resemble patch-quilt patterns. In some cases only half of the lizard is shown and in at least two cases the tails of lizards in different pho-

tographs are arranged so that they cross each other at right angles. The grouping of the distribution maps in a single section near the end both conserves space (since unrelated forms that do not overlap may be put on a single map) and makes them especially handy for one who is interested in biogeography, but it is probably not the best arrangement for persons who will be using the book in an orthodox manner; it would probably have been better for each map to accompany the form whose distribution it pictures. The name *Sceloporus undulatus fasciatus* appears on its map but its replacement, *Sceloporus undulatus hyacinthinus*, is used in the text. In the table (on page 140) "19" appears instead of "91"; there are other minor typographical errors.

ARNOLD B. GROBMAN

REPTILES GOOD AND BAD.

By William Alphonso Murrill. Published by the author, Gainesville, Florida. $2.00 (paper). 32 pp. 1945.

This is an outrageously priced pamphlet with 26 pages of text, and no illustrations. The text contains an unusual assortment of fact and fancy that is inextricably woven into a semi-conversational fabric. A few of the gems are: "[The dinosaurs'] job was to change cold blood to warm, and this they did by racing over the earth's surface in the warm sunshine." "If a big diamond-back bites you, better hurry." "The Black Rat Snake, *Spilotes variabilis*, . . . belongs with the Indigo Snake in the genus *Drymarchon*." "The use of the pit [in the Pit Vipers] is unknown but it probably serves some purpose." The arrangement of the systematic section itself seems superficial rather than truly systematic; for example, the Rhynchocephalia are omitted, no distinction is made between orders and suborders, and in the section headed "Green Snakes (Opheodrys)" is included mention of such varied forms as *Opheodrys*, *Dryophis*, and *Oxybelis*. A section on Snakes and Poetry and another on Snake Stories appear in the middle of the systematic section. The emphasis is on Florida Reptiles and largely repeats material that is more extensively and accurately presented elsewhere. There is a literature list and a reasonable plea for restraint in the "senseless killing of our innocent wild creatures." Professional zoologists will find little of value and amateurs are likely to be badly confused. This, coupled with its excessive price, forces one to withhold recommendation.

JOE A. TIHEN

BIRDS OF THE WHITE-FULLER EXPEDITION TO KENYA, EAST AFRICA. *Scientific Publications of the Cleveland Museum of Natural History, Volume IV, Number 3. By Harry C. Oberholser. Cleveland Museum of Natural History, Cleveland.* $1.00 (paper). Pp. 43-121; 14 plates. 1945.

The ornithological results of an expedition to Kenya colony made in 1930 are detailed in this report. Although the Kenya colony is perhaps better known ornithologically than any other part of Africa, the specimens collected by this expedition have extended and more clearly defined the ranges of many species. No new forms are described in this report, although Oberholser proposes several nomenclatural changes and has erected two new genera, *Fullerellus* and *Whitellus*, for two species of weaver finches. Very few data on the life history or description of the birds are included in this report, with the exception of the colors of the soft parts which were recorded in the field. There is a brief log of the itinerary with an accompanying map.

HENRI C. SEIBERT

BIRDS OF THE SEA.

By R. M. Lockley. Colour plates by R. B. Talbot Kelly. Penguin Books, London and New York. 2s. 32 pp. + 24 plates. 1945.

This small book contains twenty-four color plates of sea birds that will make a notable addition to any naturalist's library. The birds shown are those that characteristically frequent the British sea coast during the seasons; they are beautifully figured as engaged in various activities. Accompanying these plates is an account of the general habits and distribution of the birds. Here many interesting observations on behavior are presented in an attractive manner. A bibliography for further reference is included.

JOHN CUSHING

BIRDS AT HOME.

By Marguerite Henry. Illustrated by Jacob Bates Abbott. M. A. Donohue & Company, Chicago and New York. $1.50. 88 pp. 1942.

This is by all odds the finest bird book for children yet to appear, at least within present knowledge. The illustrations include a dozen full-page color plates of paintings by Jacob Bates Abbott that would make a worthy addition to any bird lover's library. There are also numbers of black and white sketches by the artist that do equal credit to his reputation. The text tells about twenty-one of our commonest, best loved birds in a lively, attractive style that will surely appeal to children and adults alike. The remarkably low price for so fine a book should also not be overlooked.

BIRDS AND HOW TO DRAW THEM.

By Amy Hogeboom. The Vanguard Press, New York. $1.00. 39 pp. 1945.

A book that can readily be recommended for children from six to ten on the grounds that it is both attractive and inexpensive. The instructions for drawing are easy to understand and are accompanied by a photograph of the bird to be drawn, as well as a short account of its habits. Nine well-known birds of diverse type are presented.

JOHN CUSHING

MAMMALS OF YUKON, CANADA. *Bulletin Number 100, Biological Series Number 29.*

By A. L. Rand. National Museum of Canada, Ottawa. 25 cents (paper). 93 pp. + 1 figure. 1945.

The Yukon territory of northwestern Canada comprises an area of over 200,000 square miles containing boreal forest, arctic tundra and mountains. The 57 mammalian species known to occur in this vast region are listed in this authoritative report, their distribution, life histories, and economic importance are briefly mentioned, and sufficient data are given for each species for their identification in the field. There are 27 clear and attractive pen-and-ink drawings, and useful bibliographic references.

In his introduction the author expresses the hope that his publication, "being the first of its kind for Yukon, may serve as a basis for further work and an incentive for additional observation of Yukon mammals." Our knowledge of the latter is still quite incomplete. That such knowledge is highly desirable is indicated by the fact that in 1942–43 the Yukon fur production amounted to nearly 53,000 pelts. In this district, inhabited by only one person to every 40 square miles, mammals can continue to thrive, if wild life regulations can be and are based on full scientific knowledge.

A. H. SCHULTZ

SCHISTOSOMOPHORA IN CHINA, WITH DESCRIPTIONS OF TWO NEW SPECIES AND A NOTE ON THEIR PHILIPPINE RELATIVE. *Smithsonian Miscellaneous Collections, Volume 104, Number 20. Publication 3841.*

By Paul Bartsch. The Smithsonian Institution, Washington, D. C. 10 cents (paper). 7 pp. + 1 plate. 1946.

PARASITOLOGY

ACARI *as Agents Transmitting Typhus in India, Australia and the Far East. Economic Series Number 16.*

By Susan Finnegan. British Museum (Natural History), London. 1s. 6d. (paper). 78 pp. + 1 map. 1945.

The literature on the Acari has long been almost as inaccessible as some of the species included in this group of ecto-parasites. Much of the early work of the Australians has been difficult to obtain in reprint form. The reviewer felt this particularly during the war, when he became interested in doing a minute problem on mites while stationed in the New Guinea area. Later, some of the desired descriptive material and keys were obtained on a visit to the University of Queensland in Brisbane, but such a pamphlet as Susan Finnegan has prepared would have been very helpful in the early days of the New Guinea campaign.

The pamphlet is logically divided into five sections dealing with: (1) the role of the Acari in transmitting typhus fevers; (2) biological factors in the transmission of typhus fevers; (3) preventive measures; (4) notes on the geographical distribution of acarine-borne typhus in specific areas; and (5), which makes up the latter half and undoubtedly most useful part of the work, the systematic section, which contains some 40 pages of specific descriptions and keys to the Ixodoidea, Argasidae, and Parasitoidea. A short section on technical methods is also included as an aid to beginners in the field.

The modest preface which apologizes for the absence of two of the more recent papers which appeared on the subject since the pamphlet went to press most certainly does not obscure the fact that irrespective of subsequent published work on the Acari, Finnegan's pamphlet will continue to be a most useful compilation of the literature for some time to come.

ALAN C. PIPKIN

LIST OF PARASITES OF DOMESTICATED ANIMALS IN NORTH AMERICA.

By Edward A. Benbrook. Burgess Publishing Company, Minneapolis. $1.25 (paper). iii + 44 pp. 1945.

This spring-bound manual lists the parasites of domesticated animals that have been reported from North America, north of Mexico. It is designed to serve as a supplement to the lectures and laboratory work of a course in veterinary parasitology.

Inasmuch as the veterinarian encounters parasites in known hosts and in certain organs and tissues of the host, the author has listed the parasites according to the various organs of the body. In naming the parasites, the scientific genus and species are used in accordance with the International Rules of Zoological Nomenclature. Synonyms are intentionally omitted by the author, but a common name for each parasite is also included. Classification has been reduced to a minimum, and it is simply stated that the parasite

belongs to a certain group of organisms, such as the protozoa, trematodes, cestodes, etc. As for morphology, only the maximum length of the organism is given.

The manual lists the parasites of horses, cattle, sheep, goats, swine, dogs, foxes, cats, chickens, turkeys, geese, ducks, guinea fowl, and pigeons. For each parasite, the various known hosts are given as well as the primary site of location within the hosts. Wherever the parasite is transmissible to man, man is included as one of the hosts. In addition, some of the wild reservoir hosts are mentioned, but the complete listing of the parasites of the rabbit and hare has not been attempted.

M. M. BROOKE

ECONOMIC ZOOLOGY

THE STORY OF PACIFIC SALMON.

By Julie V. Crandall. Binfords & Mort, Portland. $1.50. 59 pp. + 16 plates. 1946.

This little book is obviously intended to be a text for primary grades in the Pacific Northwest, and considered from this intention, it is a successful and accurate work. The spawning and nest-building activities of salmon are especially well described. The economic aspects of salmon are adequately treated, and the author has made an intelligent and impartial presentation of the problems of salmon conservation versus large dams. There is a brief appendix including various facts and figures, which could be improved by the inclusion of more up to date information and a critical examination of the conservation experiments being undertaken on the Columbia and Sacramento rivers. It is unfortunate that the specific name of the chinook salmon is spelled "chavicha" instead of *tshawytscha*. The illustrations are good.

JOEL W. HEDGPETH

THE RING-NECKED PHEASANT *and Its Management in North America.*

Edited by W. L. McAtee. The American Wildlife Institute, Washington, D. C. $3.50. xi + 320 pp. + 31 plates. 1945.

Although the pheasant was introduced in this country as early as 1790, the first successful establishment of this bird did not occur until 1881, in the Willamette Valley of Oregon. Since that time, the bird has become naturalized in all parts of the United States, wherever it has found conditions favorable for its existence. Agriculture has so reduced native game that it no longer meets the demands of present-day hunting pressure. The ring-neck has thrived in agricultural sections, and its high resistance to temperature extremes, to parasites, and to generally unfavorable environmental factors has made it a highly successful and desirable substitute for the hunter. For these reasons the Fish and Wildlife Service and state departments of conservation have intensified research on the management of the ring-neck.

After a brief historical introduction by Walcott, there is an even briefer chapter by Delacour on the classification and distribution of game pheasants. These two chapters might have been expanded to make the book fully comprehensive. The main section of the publication consists of successive chapters by different investigators on the management of pheasants in different regions of the country: in Pennsylvania and New Jersey by Bennett, in the Northeast by Pearce, in Ohio by Leedy and Hicks, in Michigan by Wight, Dalke, and English, in the Northern Prairie States by Errington, in Nebraska by Sharp and McClure, in the Intermountain Irrigated Region by Rasmussen and McKean, and in the Pacific Northwest by Einarsen. This broad survey includes all the major pheasant areas in the United States, and thus affords a basis for comparison of regional problems never before made possible in one book. The longest and most detailed report is that from Ohio, where pheasant management has been developed to a high degree. All of these reports have been brought together and edited by McAtee.

Any kind of a resumé of all the information presented would be impossible. It can be conservatively stated that a majority of all the more important data concerned with the life history of the pheasant and its attendant management problems have been thoroughly discussed and evaluated. Numerous charts, tables, and plates facilitate interpretation of the data. In spite of the fact that this is a joint effort, the amount of repetition of data is negligible, what little there is being extremely useful for comparative purposes. There are a few errors in citation, as on pp. 62 and 65, where two references are cited but not included in the bibliography, and on p. 94, where the date cited differs from that in the references. The bibliography is not extensive, merely consisting of references that the various authors found desirable. The final chapter describes the artificial propagation of pheasants and was written by Nestler and the late Colonel Bailey. It is almost a waste of words to write that this book is unreservedly recommended to all game technicians and intelligent sportsmen.

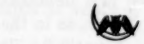
HENRI C. SEIBERT

ANIMAL BREEDING PLANS. *Third Edition.*

By Jay L. Lush. Iowa State College Press, The Collegiate Press, Ames. $3.50. viii + 443 pp. 1945.

Only minor changes, most extensive, apparently, in

the chapter on sire indexes, have been made in bringing this excellent text up to date. The review of the second edition (Q. R. B. 18: 271) is consequently still valid. Animal breeders and research workers will find this an essential book, while geneticists and all other biologists interested in selection will be amply repaid for any time spent upon it. No other book has so extensively and successfully applied to practical problems the modern concepts of population genetics and "The Genetical Theory of Natural Selection," developed by R. A. Fisher and extended by Sewall Wright to the interplay of many factors, such as mutation rates, types of breeding, size of population, and degree of isolation. Lush manages to keep the practical problems of animal breeding paramount, while theory is tested and applied to them in exemplary fashion. His exposition of the subject is always clear and logical, and is neither oversimplified nor too difficult for those who have but a slight mathematical background.



ANIMAL MORPHOGENESIS

MANUAL OF FROG AND CHICK DEVELOPMENT.

By Rev. R. H. Reis, S.J. Published by the author, Marquette University, Milwaukee. 75 cents (paper). 46 pp. 1945.

This manual is designed specifically for the study of prepared slides of frog and chick embryos, with preliminary directions for spermatogenesis in the grasshopper and oögenesis in *Ascaris*. Its frog section describes cleavage, gastrulation, and neurulation in whole eggs and sections, followed by organogenesis in serial sections of 3 mm., 6 mm., and 9 mm. embryos. Its chick section considers the hen's ovary and egg and then takes up morphogenesis and organogenesis in whole mounts and serial sections of 18 hr., 24 hr., 33 hr., 48 hr., and 72 hr. embryos.

The directions are concisely written to contain just enough information for the identification of features in the laboratory material and leave any further discussion of embryonic development to the references. At the end of the directions for each developmental stage are key letters, followed by page numbers, which refer to a master list of descriptive embryology texts. However, the author does not include the master list of references which would explain his key letters. For each stage of development the organ systems are taken up in approximately the same order. The subheadings are clearly indicated, which makes it easy to find one's way about in the manual. It follows a procedure which is standard in many elementary embryology laboratories, and instructors may find it useful for the specific material for which it was intended.

ROY GILLETTE

HUMAN EMBRYOLOGY (*Prenatal Development of Form and Function*).

By W. J. Hamilton, J. D. Boyd, and H. W. Mossman. A William Wood Book; The Williams & Wilkins Company, Baltimore. $7.00. viii + 366 pp. 1945.

The appearance of a new text-book of human embryology ordinarily is no signal event. But when the book combines a refreshing viewpoint with truly magnificent illustrations, it is deserving of more than passing comment. This statement is fully applicable to the present text by three authors, two British and one American. To them the embryo is a living thing, concerned not only with the manufacture of structures to be used after birth but also with the problem of living during a period of constant structural change and growth. Thus, as succinctly stated by one of the reviewer's colleagues, "Business is continued during alterations." The interplay of these two processes, so often neglected in embryological texts, is excellently presented in the opening chapter and thereafter is constantly kept before the reader. The factual data represent the best of current knowledge, for the authors have consistently gone to primary sources. These sources, furthermore, are appended to each chapter as reference lists that should prove of great use and stimulation to the inquiring student. A novel feature is the skillful use of the findings of experimental embryology and developmental physiology to throw light upon human development. This has been especially well accomplished in the chapters that deal with the nervous system and with "determination, differentiation, the organizer mechanism, abnormal development and twinning."

The 364 illustrations are of uniform excellence. Many of them are reproductions or adaptations of figures in the *Contributions to Embryology* series of the Carnegie Institution of Washington—a sufficient recommendation. The replacement of traditional, moth-eaten, and inadequate illustrations of human embryology is a step that should be universally welcomed. Many of the new illustrations are in color, and all are beautifully reproduced. This is in no small part due to the fact that, despite the war, the publishers were somehow able to secure the type of paper required for first-class reproduction.

It is not the purpose of this review to discuss the errors and questionable interpretations that are inevitable in the first edition of a work of this kind. These are essentially minor in nature and no doubt will be corrected in subsequent editions. On the other hand, this book sets a new standard. For it is dynamic and vital, scholarly, and extremely easy to read. This is all the more remarkable when one realizes that it was written in London during one of the most trying periods of the war. In the opinion of the reviewer, it is an outstanding achievement and is without a peer in its field.

WILLIAM L. STRAUS, JR.

CONTRIBUTIONS TO EMBRYOLOGY. *Volume XXXI, Numbers 198 to 206. Publication 557.*

Carnegie Institution of Washington. $5.00 (cloth); $4.50 (paper). xi + 175 pp.; 45 plates. 1945.

Readers of *Contributions to Embryology* will recall George L. Streeter's proposed plan, presented in 1942, for classifying human embryos "into groups or periods that represent levels in their structural organization as a whole." At the time, a list of developmental groups, about twenty-five in number, covering the important first seven weeks of embryonic life was tentatively laid out, and a detailed description of embryos of age groups XI amd XII (13 to 20 somites and 21 to 29 somites, respectively) was presented as the first of a series of papers on "Developmental horizons in human embryos." In the present volume we have the second paper of the series concerned with the next two older age groups, XIII and XIV. Group XIII includes embryos of about 4 or 5 millimeters length with an estimated ovulation age of 28± days. These embryos have definite arm-bud ridges and recognizable beginning leg buds. Embryos of group XIV are slightly older, ranging in length from 6 to 7 millimeters with an estimated ovulation age of 28 to 30 days. The arm buds have now become elongated and curved towards the body; the leg buds are finlike. Streeter designates this as the period of indentation of the lens vesicle. Sixty embryos of the Carnegie collection were available for this careful and thorough study, made from serial sections and reconstructions. The text is bountifully illustrated with excellent photographs and diagrammatic drawings—the latter very skillfully executed by the author himself.

Four other papers dealing with very early human embryonic material are found in this volume. Arthur T. Hertig and John Rock describe two ova of the previllous stage, approximately 7 and 9 days of age, recovered in excellent condition from surgically removed uteri. It is important to note that these are the earliest human ova ever to be described. They fall in age group IV, of Streeter's classification, designated as the "implanting ovum" stage. The younger, 7 day, ovum shows a solid trophoblast, while the older, 9 day, ovum has reached the stage of lacuna formation. In neither specimen does the bilaminar germ disk show any evidence as yet of developing a longitudinal axis. The amnion is forming in both ova by *in situ* delamination of primitive cytotrophoblast dorsal to the germ disk, and the primitive mesoblast is seen differentiating *in situ* from the cytotrophoblast lining the chorionic cavity. Very nice photographs and reconstructions are presented.

Andrew A. Marchetti's paper contains a description of an early implanted human ovum accidentally recovered in a curettage specimen, thus adding another embryo to the group classified as pre-villous. The estimated age of this specimen is about 13 days. In comparison with other embryos of the same relative stage of development this one is different in certain respects, such as its central location in the chorionic cavity, its rather over-developed yolk sac and over-abundance of extra-embryonic mesoblast. Also there seems more than the slight degree of infiltration in the surrounding maternal tissue that is usually associated with normally implanted ova. It should be borne in mind, however, that any two specimens agreeing in all the main features are yet to be found, even when the embryos are presumably of the same age.

The third paper, concerned with early human embryos and presented by Chester A. Heuser, John Rock, and Arthur T. Hertig, describes two very nice specimens showing early stages of the definitive yolk sac, believed to be 13½ and 16½ days old, respectively. The younger is placed quite definitely in age group VI, the older in age group VII of Streeter's classification. Axial differentiation is just appearing in the younger embryo, i.e., the primordium of the primitive streak is recognizable. The older specimen shows a definite primitive streak and the first indication of Hensen's node and head process. Here, as in the other papers, the descriptive text is bountifully illustrated with excellent photographs and diagrams.

In the fourth and last paper of the early human series, Karl Wilson describes and illustrates an apparently normal embryo of presumably 16 days' development. Particular attention is directed to the structure of the chorion and the chorionic villi.

Inés L. C. DeAllende, Ephraim Shorr, and Carl G. Hartman report the results of a comparative study, by uniform methods, of the vaginal cycle of the rhesus monkey and the human. One of the chief objects of this study was to determine to what extent results obtained with the vaginal smear methods in the monkey are applicable to the human. Ovulatory and anovulatory cycles were studied in both species, also castrates treated with estrogens alone and in combination with progesterone. From these observations a classification of the significant vaginal epithelial types of both species was made, and served as the basis for the description of the changes observed during the menstrual cycle. These studies have revealed a fundamental similarity between the vaginal secretions in the two species. Two very nice colored plates are presented. One shows the cell types found in the vaginal secretions; the other, photomicrographs of the vaginal smears during the ovulatory cycles of the two subjects.

A thorough and quite extensive study of the development, organization, and breakdown of the corpus luteum in the rhesus monkey is presented by George W. Corner with the collaboration of Carl G. Hartman and George W. Bartelmez. The report is based on 107 corpora lutea and deals with appearances revealed by routine histological methods. The text is accompanied by ten interesting and illuminating photographic plates. A very useful tabular summary is provided,

giving the chief histological characteristics of the corpus luteum from ovulation to the 12th day.

In continuation of his research on sex differentiation in the opossum, Robert K. Burns, Jr. presents two papers of considerable interest. One is concerned with the differentiation of the phallus and its reactions to sex hormones. The other deals with the effects of male hormone on the differentiation of the urinogenital sinus (from birth to the 50th day of pouch life). As to the phallus, the results show that the form of the organ as a whole is readily converted under the influence of sex hormones into a distinctly male or female type, in accordance with the hormone acting. In the case of the urinogenital sinus, clear-cut examples of both positive and negative responses to male hormone were obtained. The results are illustrated with numerous photographs and several superb diagrammatic drawings.

In addition to the above nine papers, this volume is important in that it contains an index of authors who have contributed to volumes I to XXX (1915–1942).

MARY E. RAWLES

JOURNAL OF GERONTOLOGY, *Volume 1, Number 1, Parts 1 and 2 (Non-Technical Supplement), January 1946.*

Edited by Robert A. Moore. Published Quarterly for The Gerontological Society, Inc., by Charles C. Thomas. Editorial office: 507 South Euclid, Saint Louis 10, Missouri; publication office: Springfield, Illinois. Subscription prices a year: in the United States, Canada, Mexico, Cuba, Central and South America, $6.00; Non-Technical Supplement, separately, $3.00; in other countries $6.50, Supplement $3.50. Single copies $1.50; Supplement $1.00.

This new journal is the official organ of the recently organized Gerontological Society and has been established through the aid of a grant by the Josiah Macy, Jr., Foundation. It deserves wide attention, as it presents a two-fold novelty: the emergence of a new biological and medical field; and a new type of scientific journalism.

It is hardly necessary to repeat that our present population trends make an increasing interest in the biology and pathology of old age inevitable. Scientific research in gerontological problems is likewise increased and due to increase far more rapidly in the future. The new journal therefore fills a secure place. It is very well printed, on fine paper that permits half-tone reproductions of excellent quality. The contents of the first issue are of considerable interest:

Gerontology, by Lawrence K. Frank; Increase in Mortality as Manifestation of Aging, by Henry S. Simms; Age of Stem Tissue and Capacity to Form Roots, by P. W. Zimmerman and A. E. Hitchcock; Aging in Nutritionally Deficient Persons, by Tom D. Spies and Harvey S. Collins; Prolongation of Life with Prevention of Leukemia by Thymectomy, by Jacob Furth; The Hodson Community Center, by Dora Fuchs and Harry Levine; Budgeting for Social Security, by W. R. Williamson; The Aged in Primitive Societies, by Leo W. Simmons; Involution of Tissues in Fetal Life, by Arthur T. Hertig; Shakespeare's Attitude Towards Old Age, by John W. Draper. Current Comment. Organization Section. Gerontologic Reviews. Book Reviews. Index to Current Periodical Literature.

The journalistic novelties are well worth note. Each article is followed by the author's full address, and by four abstracts, respectively in English, French, Spanish, and Russian. A separate non-technical supplement is also published, to which those who wish to do so may subscribe alone. It contains rewritten non-technical digests of the articles in the regular journal, prepared for laymen interested in the field. This seems a most promising effort to narrow the chasm between scientific endeavor and the remainder of the social order, and to promote not only an interest in science but to undertake a phase of general scientific education. The experiment is most praiseworthy and its outcome will be watched with great interest.

BENTLEY GLASS

ANIMAL MORPHOLOGY

ANATOMY OF ANIMALS.

Edited by Yvonne Francoise Jossic. H. C. Perleberg (Albert A. Lampl, Successor), Philadelphia. $7.50 (paper). 4 pp. + 36 plates. 1946.

This volume contains, as it says on the cover, 239 illustrations. What it does not say on the cover, or anywhere else in the volume, is that they are 239 illustrations reproduced without change from the *Handbuch der Anatomie der Tiere für Künstler* by W. Ellenberger, H. Baum, and H. Dittrich, and published by Dieterich in Leipzig. Whatever may be the legality of copyrighting in this country material copyrighted abroad some years ago, the complete omission of any reference whatsoever to the sole source of an entire book is surely an amazing if not a contemptible act and one that detracts from the scientific value of the work.

The usefulness of the book would have been increased if even the German title had been translated in full, because the material is presented primarily for artists. The figures lack the clarity and are only about half the size of the originals. Nevertheless, they are beautiful things, comparable to the superb anatomical drawings of Albinus and of Coiter. The emphasis is on the skeleton, the superficial musculature, the head, and the feet. The animals pictured include the horse, cow, lion, dog, deer, and goat. Unfortunately, the text of the original (which is partly in English) is omitted, so that the numerous letters and numbers on the drawings merely clutter them up.

These plates will serve a purpose, but in the future it is greatly to be hoped that American publishers will give us illustrations that are at least equal to those produced abroad years ago, and that, in the name of common decency as well as scientific accuracy, the source of the material will be given.

GAIRDNER MOMENT

AN INTRODUCTION TO HUMAN ANATOMY. *Third Edition.*

By Clyde Marshall, revised by Edgar L. Lazier. W. B. Saunders Company, Philadelphia and London. $2.50. xi + 418 pp. 1946.

With the existing abundance of heavy textbooks on human anatomy which supply data to the last detail, there is a present need chiefly for much smaller "anatomies" that give the most essential information in a carefully selected and balanced fashion. The present little volume can be highly recommended as a reliable *Introduction* to human anatomy and as a helpful preparation for the student who later has to find his way through far larger textbooks and reference works. This *Introduction* is clearly written, and is excellently illustrated with more than 300 well-chosen figures. It is limited to the most significant facts, helpful in explaining terminology, gives adequate space to information regarding development and function, and contains a good bibliography and serviceable index. The present, third edition has been somewhat enlarged and carefully revised throughout.

A. H. SCHULTZ

STRUCTURE AND FUNCTION OF THE HUMAN BODY.

By Ralph N. Baillif and Donald L. Kimmel. J. B. Lippincott Company, Philadelphia, London and Montreal. $3.00. xii + 328 pp.; 2 plates. 1945.

The purpose of this text, in the words of the authors, is to provide a very elementary and simple description of the systems of the body and their functions, primarily for the use of students of nursing. In other words, it is intended as a presentation of principles rather than a compilation of facts. The book is well illustrated by a series of very good, original sketches. The advantages of an elementary presentation are almost invariably offset by the resulting static picture obtained, and by the fact that actually nothing is so simple. Thus, such a presentation is an artifice of teaching method, having little relationship to the complexity and variability of living systems. The weakness, to the good student, is in the shallowness of approach, which prevents him from obtaining a dynamic point of view. The text is somewhat uneven, treating certain systems in more detail than others. Charts are given, for example, detailing digestive enzymes and vitamins, and hormonal syndromes are illustrated in several plates. Equally dramatic nervous afflictions are not mentioned, nor are details of the organization of the central nervous system. No bibliography is included, which is, in the eyes of the reviewer, a violation of a basic method of teaching in any subject.

JAMES M. SPRAGUE

ANATOMY OF THE HEAD AND NECK.

By R. T. Hill. Lea & Febiger, Philadelphia. $2.75. 125 pp. 1946.

This little book, intended for dental students, is limited to the gross anatomy of the head and some parts of the neck of adult man. The subject is presented in a purely descriptive manner as simple morphology, except for a discussion of the action of the masticatory muscles. Directions for practical procedures in dissecting have been inserted in somewhat random fashion. Nothing is mentioned of embryology nor of growth and development in general. The dentition is not included. Except for two brief chapters, dealing with "some lesions and syndromes" and "infection routes of the oral cavity," this volume contains nothing that can not be found also in standard textbooks of anatomy and dissecting manuals. Most of the 30 text figures are copied from the literature. The few new drawings are very crude and could easily have been replaced by far better ones, plentiful in the literature. For an anatomical textbook this volume is low-priced; that may justify its publication.

A. H. SCHULTZ

THE EXTREMITIES.

By Daniel P. Quiring, Beatrice A. Boyle, Erna L. Boroush, and Bernardine Lufkin. Lea and Febiger, Philadelphia. $2.75. 117 pp. 1945.

The purpose of this little book is "to make clear to the student the origin, insertion, action, and arterial and nerve supply of the muscles of the upper and lower extremities together with their motor points." The material is presented in the form of an atlas consisting of 106 diagrams, each of which deals with a single muscle. References to the appropriate pages in both Gray's (24th edition) and Cunningham's (7th edition) texts are included. The figures have been executed with care and clarity. This book is a useful supplement to, although it does not replace, the standard anatomical atlases.

WM. L. STRAUS, JR.

A TEXT-BOOK OF NEURO-ANATOMY. *Fourth Edition.*

By Albert Kuntz. Lea & Febiger, Philadelphia. $6.50. 478 pp. 1945.

The last edition of this standard text-book appeared as late as 1942; but the accretion of neurological knowledge has been so rapid that the author has found it necessary to revise thoroughly, and in part to rewrite, the text in order to keep it up to date. The sections especially affected relate to the diencephalon, the corpus striatum, the pathways for visceral impulses, the cortical projection areas, and the connections of the cerebral cortex with subcortical centers. This revision has fortunately been accomplished without expanding the size of the book. Some figures have been replaced, and new ones have been added.

THE AUTONOMIC NERVOUS SYSTEM. *Third Edition. By Albert Kuntz. Lea & Febiger, Philadelphia.* $8.50. 687 pp. 1945.

This has long been one of the standard reference books on the autonomic nervous system in the English language. By virtue of its excellent correlation of morphology and physiology, it will no doubt continue to appeal to students and workers in a variety of fields. Eleven years have elapsed since the publication of its second edition. During that time the accumulation of new data has been such as to require a thorough revision and rewriting of the text, which has been enlarged by fifteen per cent. A number of new illustrations have been added.

ANIMAL PHYSIOLOGY

THE CIRCULATION OF THE BLOOD *and Andrea Cesalpino of Arezzo.*

By John P. Arcieri. S. F. Vanni, New York. $4.00. 193 pp. 1945.

The author takes up the old controversy over the priority in the discovery of the circulation of the blood. I feel that he is rather successful in establishing the claims of Andrea Cesalpino of Arezzo (1525–1603) and therefore his book should be read by those interested. He is much less convincing when minimizing the merits of William Harvey, whom he tries to dismiss as a mere plagiarist. It is sad to see that the author suffers fundamentally from just the sort of patriotic subjectivism with which he reproaches so vociferously the Anglo-Saxon medical historians. This becomes very obvious when he tries to elevate the toherwise admirable Spallanzani at the expense of Haller and Hales, or when he makes Cesalpino the main protagonist of a new botany. The priority complex, a subspecies of the inferiority complex, has been particularly virulent among the more recent Italian authors. This is all the more grotesque because the Italians have so many true priorities to claim, both good and bad, that they need not grasp for others. The book deals with an important problem and contains valuable material. Its polemic subjectivism is probably responsible for bad organization of the material, and its English is simply atrocious.

ERWIN H. ACKERKNECHT

PHYSIOLOGY OF FARM ANIMALS. *Third Edition. By F. H. A. Marshall and E. T. Halnan. Cambridge, at the University Press; The Macmillan Company, New York.* $4.50. xi + 339 pp. 1945.

This is the third edition of a standard work which was first published in 1920. It is, the preface states, "intended for students of Agriculture who wish to obtain some knowledge of the processes of Physiology as they occur in domestic animals, as well as to act as a guide to the modern science of Animal Nutrition. It will also prove of service to veterinarians." If this is the only textbook of physiology available to a student of agriculture, his concept of the subject will include descriptive information on histology; the chemistry of foods; minerals, water, and vitamins; digestive organs; blood and the organs of circulation; respiratory organs; excretory organs; and so on for each of the organ systems of the body.

Of the one hundred and nineteen figures found in this book approximately ninety-five per cent have morphological implications with only the most indirect relation to the functioning of the body. In short, this text, however adequate it may be in the subjects with which it deals, will fail to convey to the student the concept of homeostatic physiological mechanisms, in which the organ systems are interrelated in a dynamic equilibrium. Much less will the student come to understand the types and limits of physiological capabilities of the body under conditions of stress as opposed to those of rest. It is also true that his knowledge will not be adequately up to date in the important fields of the physiology of reproduction, the nervous system, and the circulation.

Perhaps students of agriculture and related subjects do not require this type of knowledge for the performance of their professional or other duties. It seems unfortunate, however, that in a book emanating from the pen of such a distinguished and effective teacher and research worker as Marshall, there is not instilled both the inquisitiveness and the results of the highly effective research along applied and scientific lines which has made the School of Agriculture at Cambridge preeminent in its field.

S. R. M. REYNOLDS

PHYSIOLOGY AND ANATOMY. *Fifth Edition. By Esther M. Greisheimer. J. B. Lippincott Company, Philadelphia, London and Montreal.* $3.50. xiv + 841 pp. + 3 plates and 2 charts. 1945.

This is the fifth edition of one of the standard textbooks for student nurses. In its coverage of anatomy and physiology it has attempted to present biological principles in relation to the basic facts of structure and function of the human body, and their application to medicine. It is a difficult task to present the huge number of facts in such a way that a readable, coherent story is the result, but the author has accomplished this to a remarkable extent. Most of the many illustrations are good, and those on the muscular system are excellent. The circulatory system, on the other hand, is poorly illustrated, and the discussion of vascular changes at birth should be rewritten to include recent experimental data. Considerable emphasis has been given to subjects important to the training of nurses, such as nutrition and the reproductive system. The treatment of the central nervous system is inadequate for a basic understanding, and particularly is this true of the rapidly growing field of neurophysiology. The reviewer would suggest the addition to the list of references of Le Gros Clark's *Tissues of the Body*, the most dynamic and interesting general presentation yet written.

Specific criticisms are of course applicable to any text, but in general the author has written a very good and useful book. The price is very reasonable.

JAMES M. SPRAGUE

SYNOPSIS OF PHYSIOLOGY.

By Rolland J. Main. The C. V. Mosby Company, St. Louis. $3.50. 341 pp. 1946.

The need for a concise summary of the essential facts of physiology is recognized by teachers and students of physiology, and by physicians and others who must refresh their memories for special examinations and sundry other reasons. This book is an attempt to fill that need. There have been others, some of which have enjoyed considerable favor by students. The later editions of Bainbridge and Menzies and the early editions of Wright, were much used in this way. Until now there has been no effort by an American physiologist to write such a book for physicians and senior medical students. This pocket-sized book is written for such a group of readers.

The organization of the text does not follow the conventional pattern found in the larger text-books of physiology. The nine chapter headings are as follows: Protoplasm and the Cell; Environmental Adaptation of Cells and Homeostasis of the Body; Circulation, Blood, and Tissue Fluids; Respiration; Digestion; The Nervous System; Sensation; Endocrines and Reproduction; Physiology of Miscellaneous Systems, Functions and Organs. This list, with the catch-all at the end, should admit treatment of all bodily activities. In a limited sense, it does so. The chapters are subdivided into sections, and there are clear, boldface titles heading the majority of paragraphs, each one dealing with a separate subject. In similar fashion, to help the reader who uses the *Synopsis* for reference purposes, there is a very extensive index, listing more than eighteen hundred separate references or subjects, and occupying nearly ten per cent of the pages of this small book. The index is cross-referenced very well. These virtues of the book will make it of considerable value to many who use it. But there is danger that many students will be led astray by this volume. Its compactness, its apparent broad scope, and many helpful figures and tables will appeal to medical students not well-grounded in the subject, and by their use, such students will not acquire a good understanding of physiology if they rely on this volume. There are several reasons for this.

The principal inadequacy of this *Synopsis* seems to be that the subject simply does not lend itself to brevity and balanced presentation simultaneously. Another reason is that the problem of selecting and eliminating subjects for fuller comment is one which will depend upon the interests, knowledge, and convictions of the author. In the case of the present book, relatively up-to-date discussions,—synopses,—are given concerning certain aspects of cell function and the internal milieu of the body. On the contrary, the treatment of the circulation, for example, is insufficient. Similarly for the central nervous system; the presentation is reminiscent of the texts of twenty years ago, and lacking in a concept of the interrelation of the several parts of the nervous system, as made up of many units but necessary almost as a whole for normal function. The miscellaneous functions described in the last chapter include a discussion of postural reflexes (which could be considered more effectively in the chapter on the nervous system), aviation physiology (three pages), the glottis, the kidney, the bladder, the liver, etcetera, etcetera, through secretion, muscle, respiration, sleep, skeletal muscle again, and finally, senescence.

There is still need for a book with the purpose of this one. Perhaps it would be a companion volume to a large standard text, integrated with it by the authors of such a text. For the present, one must conclude that there is no short-cut to a knowledge of physiology.

S. R. M. REYNOLDS

EXERCISES IN HUMAN PHYSIOLOGY (*Preparatory to Clinical Work*).

By Sir Thomas Lewis. Macmillan and Company, London. $1.25. xiv + 103 pp. 1945.

This book is of great potential value. It is not to be judged by the number of its pages, nor in a sense is it to be gauged by its contents. Its value is to be found in the purpose of the book and the uses to which it

lessons may be put in the development of keenly observing clinicians. The declared purpose of the author is to provide a bridge by which the medical student may pass safely and readily from the laboratory to the bedside; from the animal to the patient; from the specialized technics of experimental procedure to a readily applied diagnostic routine.

Most courses in medical school physiology commence with general physiology or something akin to it, and proceed to highly specialized technics in mammalian experiments. When experiments on human beings are carried out, the technics are usually difficult or highly specialized. It is the purpose of this book to bring together a group of systematic procedures which are based on situations that demonstrate physiological principles but which may be carried over with profit into practice by the student of medicine. The experimental procedures presented may be grouped into those primarily concerned with vascular phenomena, and those concerned with the "cutaneous system." Many of the procedures described are taught to American medical students, if not in physiology, then in physical diagnosis in medicine or in dermatology. Other experiments, however, are unfamiliar as laboratory procedures to a large proportion of teachers. Sir Thomas's contention is that by bringing these procedures together, with the addition of others as situations permit or require, a relationship will be clear to the student of the direct applicability of physiological principles to many diagnostic procedures. The student, moreover, will acquire experience in these technics in normal situations, and he will gain valuable experience in working with human beings as subjects.

Some of the experiments which are described would add a great deal to most medical school curricula in this country as practical teaching adjuncts. These include: visible vascular pulsations; venous pressures; a carotid sinus pressure experiment; general vasodilatation and sweating; calorimetry and blood flow; use and blood flow; skin color and its relation to temperature and blood flow; erythralgia; goose skin and axone reflexes; paralysis of cutaneous nerves, and ischemic pain. This enumeration is but a partial list of experiments that might be mentioned.

The book is so written that, to be of value, one would have to have considerable experience in physiological technics in order to use the book to best advantage. There are few illustrations, and very few references to much basic work. A helpful feature, albeit very cursory in style, is a section entitled "application" at the end of each section or group of experiments. The book should be most helpful to those teachers of physiology who, believing that repetition is the soul of pedagogy, wish to incorporate many of these experiments and others like them into existing courses of physiology. If this were done generally, the effectiveness of much of our teaching would be immeasurably enhanced, and the primary purpose of this book would be fulfilled: principles of abstract physiology would find their application in modern medicine.

S. R. M. Reynolds

The Biology of Flight. (*Air-Age Education Series*). *By Frederick L. Fitzpatrick and Karl A. Stiles. The Macmillan Company, New York.* 64 cents. viii + 162 pp. 1942.

This small volume consists of a survey of the possibilities and problems presented by flight. The first two chapters contain brief descriptions of mechanisms employed by certain plants and animals to permit various degrees of airborne travel. The mechanisms of flight are discussed. The following five chapters deal with problems presented to the human organism by ascent into the upper atmosphere in modern aviation. They are concerned with respiratory problems, the necessity for breathing oxygen, altitude sickness, consequences of pressure changes, acceleration and deceleration, motion sickness, the temperature changes encountered, problems associated with sense organ reactions, susceptibility to fatigue, and the physical fitness necessary for flight. The final chapter contains a discussion of air travel and disease control. Although the book does not delve very deeply into the physiological or technical problems of flight, it is nevertheless a correct and thorough survey of the field. It is well adapted to give a lay reader an adequate understanding of the biological problems of flight, and the material is sufficiently well presented to retain the reader's interest.

Chandler McC. Brooks

Biological Actions of Sex Hormones. *By Harold Burrows. University Press, Cambridge; The Macmillan Company, New York.* $8.50. x + 514 pp. 1945.

Our knowledge of the hormones and of the reactions of living tissues towards them is rapidly extending. The chemistry of the compounds formed in the gonads, the pituitary, and the adrenals has made great progress during the last few years. At the same time much has been learned about the effects of these substances on the structure and function of the body. The author has been very successful in presenting a coordinated summary of experimental inquiries in this field. He has confined his review almost entirely to biological work performed in the laboratory. This is to be regretted because clinical investigation has proved to be a most valuable source of knowledge in endocrinology. The book is written very clearly, and the author has given a lot of thought to terminology. For instance, he criticizes the term "bisexual action" of a hormone. This term arises from the concept that re-

gards each of the two main groups of gonadal hormones as arising only in the appropriate gonads and as acting only on the organs of one sex. Burrows stresses the point that there is no essential antagonism between the testis and ovary, nor between the individual of one sex and the gonads of the other.

One of the best chapters in this book is concerned with the factors in the causation of mammary cancer. The role of estrogens and of hereditary factors in the etiology of mammary cancer in mice is clearly demonstrated. Experiments have proved that there are two different heritable agencies which favor the development of mammary cancer. These are genic and non-genic. The latter, identical with Bittner's milk factor, is possibly a virus. Cancer research and endocrinology have found a lot of common ground recently, and the author's own important work on the biological actions of the steroids has been carried out at the Royal Cancer Hospital in London. The effects of the androgens on the structures of the body are presented excellently and in great detail; it is unfortunate that the chemical effects have not found equal consideration.

Burrow's work should be read by everybody interested in the fundamentals of endocrine physiology. The author has fully achieved his goal of supplying a trustworthy foundation for further progress in both sex-hormone research and clinical practice. The bibliography of nearly 2000 references will prove to be of greatest value to the research worker.

WALTER FLEISCHMANN

VITAMINE UND HORMONE *und ihre technische Darstellung. Erster Teil: Ergebnisse der Vitamin-und Hormonforschung. Zweiter Teil: Darstellung von Vitaminpräparaten. Dritter Teil: Darstellung von Hormonpräparaten (ausser Sexualhormonpräparaten).*

(I) By Hellmut Bredereck and Robert Mittag; (II) by Franz Seitz; (III) by Erich Vincke. Advance Scientific Publishers, New York (Mary S. Rosenberg, New York). (I) xv + 138 pp. + 1 chart; (II) xi + 205 pp. + 3 charts; (III) xv + 162 pp. 1944.

This set of three booklets, published in 1938 for the use of chemical engineers in Germany, contains reviews of the literature on vitamins and hormones. The literature is included only up to 1936, so that the great advances in this field during the last ten years are omitted. The first volume deals with the biology and chemistry of the vitamins and hormones, in 112 small pages. The second and third volumes are concerned with the manufacture of these substances. The bibliography includes a list of patents which should prove useful to manufacturers of hormones and vitamins. The indices are adequate.

WALTER FLEISCHMANN

VITAMINS AND HORMONES. *Advances in Research and Applications. Volume III.*

Edited by Robert S. Harris and Kenneth V. Thimann. Academic Press, New York. $6.50. xv + 420 pp. 1945.

The eight articles presented here again reflect a catholicity of interest. Critical reviews, as these may fairly claim to be, are of special value when the author brings to them an insight into the trends and future of the topic treated, or makes them the background for fresh interpretations or new theories. As particularly representing the first approach is B. C. J. G. Knight's "Growth Factors in Microbiology" and representing the latter, Nachmansohn's "Acetylcholine in the Mechanism of Nerve Activity," where for the first time one has an opportunity to examine this author's views in extended form. The "Anti-Pernicious Anemia Substances of Liver" receive a judicial treatment by SubbaRow and his associates, and although the time is apparently not ripe for reconciling the conflicting schools, at least the source of disagreement seems to be defined. E. C. Dodds, in a short and entertaining chapter, "Possibilities in the Realm of Synthetic Estrogens," shows that the Synthetic Chemist in his Parnassian abode is mortal too, and that the melting-point is not necessarily mightier than the mouse.

Two chapters, "On the Synthesis of B Vitamins by Intestinal Bacteria" (Najjar and Barrett) and on "Sulfonamides and Vitamin Deficiencies" (Daft and Sebrell), tend to supplement each other in covering an increasingly important aspect of nutrition. In discussing the "Interrelations of Vitamins," Moore provides an effective classification of the various possible intergrades of such actions, and brings together a hitherto diffuse literature.

Zondeck and Sulman also cover a wide field in the "Mechanism of Action and Metabolism of Gonadotrophins"—this chapter may suggest to the reader more than anything else the need for a redoubled chemical onslaught on these substances. Finally in Warkany's chapter on "Manifestations of Prenatal Nutritional Deficiency," from an emphasis on the minutiae of the effects of protein, mineral, and vitamin deprivation, there emerges a story of the highest sociological interest and importance.

H. R. CATCHPOLE

STUDIES OF THE PHYSIOLOGY AND TOXICOLOGY OF BLOWFLIES. *10. A Histochemical Examination of the Distribution of Copper in Lucilia cuprina; 11. A Quantitative Investigation of the Copper Content of Lucilia cuprina. Bulletin Number 191.*

By D. F. Waterhouse. Council for Scientific and Industrial Research, Melbourne, Australia. Free upon request (paper). 39 pp. + 1 plate. 1945.

ANIMAL NUTRITION

HIDDEN HUNGER.

By Icie G. Macy and Harold H. Williams. The Jaques Cattell Press, Lancaster. $3.00. vii + 286 pp. 1945.

Hidden Hunger is an authoritative and reliable book on human nutrition, but it is a misfit in a series of popular books on science. The chapter headings, like the title, are stimulating and effective, but there, for the most part, good writing stops. The text is typical of scientific style at its worst—it is dull, wordy and repetitious, often laboring the obvious, and quoting at length many long, documented selections that often do no more than say the same thing all over again. As a sample of the text one might quote the following: "True 'underweight' is not determined necessarily by nonconformance with tables showing average weights for sex and height, but is a result of malnourishment." (p. 82). There is essentially nothing here not to be found in other compilations, while this one cannot begin to compare in interest with such books on the subject as those by Graubard or Furnas and Furnas, nor in simplicity, brevity, and graphic approach with R. H. Williams' recent book, *What to Do About Vitamins* (see Q.R.B. 21: 202).

BENTLEY GLASS

BIOCHEMISTRY

DIE GLYKOSIDE. *Chemische Monographie der Pflanzenglykoside. Second Edition.*

By J. J. L. van Rijn. Second Edition by Hugo Dieterle. (Gebrüder Borntraeger); J. W. Edwards, Ann Arbor, Michigan. $16.00. viii + 620 pp. (1931); 1945.

This book is a lithoprint of the second revised and enlarged edition of an old but popular monograph on the chemistry of plant glycosides. It was apparently designed to serve as a reference book, as it is a compilation of all the facts available at the time on the chemistry of this extensive group of substances. It should be especially valuable for pharmacologists, botanists, and those interested in carbohydrate chemistry.

The authors define glycosides as including the large group of chemical compounds, occurring almost exclusively in the plant kingdom, which certain agents may hydrolyze to form one or more sugars and one or more compounds of heterogeneous types. The glycosides are listed in order according to the plants from which they are derived. The authors admit that this is not ideal for many reasons. One is that the same glycoside may be derived from different plant families. The chemical formula, properties, and the constitution of the Aglycon portion of the compounds is given, in so far as this is possible. The physiological action of some of the glycosides are given when these have been studied.

The reviewer is not qualified to comment on the correctness of all the diverse and heterogeneous material presented, but it appears to be carefully and laboriously assembled. It was of interest to note among the glycosides such compounds as digitalis, digitoxin, and related substances. Hesperidin and hesperetin, which have recently gained recognition as members of the vitamin P group, were discussed in some detail. The references indicate that this glycoside was isolated as early as 1828. The mills of the gods do grind slowly! Since this book was published in 1931, there is no reference to the vitamin P nature of hesperidin.

In contrast to the first edition, the references are given at the foot of each page. The book has an extensive index, which lists the chemical compounds and botanical names in separate sections.

FRANK H. J. FIGGE

THE CHEMISTRY OF ANESTHESIA.

By John Adriani. Charles C. Thomas, Springfield, Illinois. $7.00. x + 536 pp. 1946.

The author makes the significant observation that, "of all the fundamental sciences, chemistry has reflected itself most widely in medicine." In the medical specialty of anesthesiology, the chemist has played a dominant role since the days of Horace Wells and Wm. Thomas Green Morton. Every new anesthetic that comes to trial in the hands of the anesthetist and every modern anesthetic agent in use today represents a medical triumph for the organic chemist, an indebtedness the clinician is often prone to overlook. Adriani rightly deserves the acclamation which his volume is receiving from anesthetists, pharmacologists, and chemists. *The Chemistry of Anesthesia* is a volume unique in its field, its author has scored a shining mark and made a noteworthy contribution to the subject.

This book is intended for use by postgraduate students of medicine specializing in anesthesia, hospital residents, and students of the subject from the many cognate sciences. The text is divided into three parts. Part One deals with inorganic chemicals used as anesthetic agents or in the art of anesthesia, the physical laws of gases, the measurement of gas volumes by anesthetic machines, and the basic laws of inorganic chemistry related to anesthesia. A chapter is devoted to the physico-chemical principles of carbon dioxide absorption in rebreathing appliances.

The second section, nearly 200 pages in length, is devoted to the chemistry of the organic compounds used as depressant drugs. A very complete chemical description of each important anesthetic agent is included, with the history of its discovery and its

preparation and physical properties. Specific information of special interest to the anesthetist, e.g., blood concentration during anesthesia, explosive hazards, anesthetic contraindications, etc., are also included in this section. An interesting and suggestive introduction to each portion of the text provides the student with a chemical background designed to indicate the relationships among the organic anesthetics and to suggest new anesthetic possibilities.

Part three, of 131 pages, deals with the biochemical aspects of general anesthesia, including theories of narcosis, chemical changes in tissues following the administration of anesthetics to man and animals, detoxification mechanisms, toxicology, and the biochemical aspects of local anesthesia.

The general survey of the theories of anesthesia presents a comprehensive picture of the subject and indicates only too well the recognized inadequacy of our knowledge of the mechanism of narcosis. An extensive bibliography of this subject directs the reader to adequate collateral material. The discussion of the chemical effect of anesthetics upon tissues and tissue functions collects in one volume a tremendous amount of data previously scattered in the literature. This section alone would warrant publication of the volume; workers in the field of anesthesia will find it most useful. This third portion of the book also includes a few pages on the toxicology of anesthetic drugs, a discussion too brief to be of value and a subject more adequately covered in volumes devoted to general toxicology.

The book concludes with an elaborate bibliography and a glossary of terms, both very useful to the student, although one might wish for specific journal references in the body of the text. The volume is well printed and bound and relatively free from typographical errors. The reviewer commends the book to anesthetists, pharmacologists, and chemists and predicts its wide acceptance in the biological sciences generally.

C. JELLEFF CARR

COLLOID CHEMISTRY: *Theoretical and Applied. Volume VI. General Principles and Specific Industries, Synthetic Polymers and Plastics.*

Collected and Edited by Jerome Alexander. Reinhold Publishing Corporation, New York. $20.00. vii + 1215 pp. 1946.

The 71 papers in this mammoth volume deal mainly with various technological applications of colloid chemistry in industry, approximately one-half of them being devoted to specific industries or industrial operations, and the other half to the synthetic resins and plastics. The most strictly biological paper is a very extensive (106-page) review, by C. K. Tseng, of the phycocolloids, useful seaweed polysaccharides that include agar. A number of other articles will have theoretical value, especially to biologists interested in high polymers and macromolecules. In spite of its usefulness as a reference, this is so expensive a work that, unlike volume V of the series, its purchase by the individual biologist is hardly warranted. The biochemist may find it a worth-while investment. It should be in every good institutional library.

MICROBIOLOGY

MARINE MICROBIOLOGY. *A Monograph on Hydrobacteriology. A New Series of Plant Science Books, Volume XVII.*

By Claude E. ZoBell. The Chronica Botanica Company, Waltham, Massachusetts; G. E. Stechert and Company, New York. $5.00. xv + 240 pp. 1946.

In the Foreword Waksman remarks: "This book should prove useful as a forerunner of many future investigations in the field of marine bacteriology, or as the author prefers to designate the subject, marine microbiology." This preference on the part of ZoBell's is hardly an adequate reason for the use of a title which suggests an account of the nature and activities of marine microorganisms. Instead, the contents are almost exclusively limited to a rather elementary treatise of the bacterial population of the ocean, with a few brief sections on bacteria in marine air, in brines, and in salt- and fresh-water lakes. The yeasts and molds are dealt with in 7 pages; beyond the re-iterated statement that the phytoplankton is largely responsible for the production of organic matter in the ocean, the algae are not mentioned; nor are the protozoa.

The first half of the book is occupied by a general characterization of the marine environment, a detailed description of methods for collecting samples, and for the enumeration of bacteria, followed by a discussion of the distribution of bacteria in seawater and bottom deposits.

The second half contains a number of chapters on the nature and activities of the bacteria. The one on characterization (morphological, cultural, and physiological characteristics) is brief to the point of being fragmentary. It is also obviously dominated by the standardized methodology for the study of pure cultures of bacteria which, so far, has achieved little more than conventionalizing a number of procedures the general value of which is highly problematical. Even where statements are made concerning more fundamental metabolic characters, their interpretation is often far from clear. The sentence: "Nearly all of the bacteria isolated from seawater or marine mud have proved to be facultative aerobes" (p. 117) is a case in point. It would seem to imply that these organisms can grow in the presence as well as in the complete absence of oxygen; yet it is common experience that the great majority of species of typical water bacteria,

including the marine forms, behave like strict aerobes. Another example is the claim: "As a group, marine bacteria are more weakly saccharolytic and probably more strongly proteolytic than are either soil or freshwater bacteria." How is this to be understood when the next paragraph begins with the announcement that.... "ZoBell and Grant present evidence which suggests that all heterotrophic marine bacteria are able to assimilate glucose...."? It would seem logical to conclude that, as a group, marine bacteria represent chiefly autotrophic types, but this is contradicted by the evidence.

Included in this chapter is a list of the bacterial genera, compiled from Bergey's *Manual of Determinative Bacteriology*, with annotations indicating the occurrence and relative abundance of representatives of these genera in marine habitats. To the beginning student this list is rather meaningless since the characterization of the genera is omitted; to the more experienced bacteriologist it is either obvious (as, for example, the preponderance of polarly flagellated, non-sporeforming bacteria, long known as the chief representatives among 'water bacteria,' and the absence of bacteria characteristically encountered in milk and dairy products, in the intestinal tracts of mammals, or as causative agents of human diseases), or contradictory; thus, the distribution of members of the genus *Bacillus* is indicated by a 4-plus sign, as are the genera *Pseudomonas*, *Vibrio*, and *Achromobacter*, whereas earlier in the text the statement can be found that "Sporeforming bacteria do not appear to be particularly abundant in the sea."

The lack of adequate characterizations of bacterial genera and species is all the more regrettable because many places in the book are occupied by more or less extended lists of specific names, often enumerations without any connotation.

A specific treatment of the role of bacteria in the cycle of matter in the ocean is the subject of the next few chapters. Like much of the book, it is a combination of elementary principles, familiar from various textbooks on general and soil bacteriology, and a rather uncritical compilation of data from the literature.

When, in 1933, Benecke published his treatise on *Meeresbakteriologie* as a section of Abderhalden's *Handbuch*, he stressed in many places the lack of knowledge concerning specific processes in the ocean, and the need for new methods of investigation. ZoBell's book is rather eloquent evidence for the conviction that little of fundamental significance has been achieved during the intervening years. As an annotated bibliography it will be of use, especially since Benecke's contribution contains references only up to 1932, and is not available in an English translation. But as a monograph it does not reach a very high standard, and seems, on the whole, rather trifling.

The execution, like that of the other volumes of the "New Series of Plant Science Books," published by the Chronica Botanica Co., is excellent.

C. B. VAN NIEL

ELEMENTARY BACTERIOLOGY. *Fifth Edition.* *By Joseph E. Greaves and Ethelyn O. Greaves. W. B. Saunders Company, Philadelphia and London.* $4.00. xvii + 613 pp. 1946.

The scope of this textbook is broad in its conception and execution. With the introductory chapters, the sections on physiology and the effects of environmental factors take up nearly half of the book. Following this are chapters on the bacteriology of water, foods, sewage, air, etc. The remainder, considerably less than half of the work, is devoted to immunity and to pathogenic organisms or states. Some space is allotted to material on the higher fungi; animal infections are not discussed—with the exception of malaria, which is included as an insect-borne disease. Laboratory methods and procedures are not presented. Each chapter has a few references and questions appended. The index is adequate.

For an elementary text the book contains a great deal of information, so that a student need not be introduced to bacteriology in a sketchy fashion. It should serve well its designated purpose as a basis for a first course in the fundamentals of the science.

HARRIETTE D. VERA

ESSAIS SUR LA BIOLOGIE DES MICROORGANISMES. *By Raymonde Giabicani. Société d'Impressions Typographiques, Nancy.* 300 ft. (paper). 223 pp. 1945.

Part I of this thesis compares the action of the *d-*, *l-*, and *dl-* isomers of cysteine, methionine, alanine, histidine, and valine as the sources of nitrogen in synthetic liquid media, upon the growth and chromogenesis of dissociated (smooth and rough) types of *Serratia marcescens*, *Pseudomonas chlororaphis*, *Ps. caryocyanea*, *Bacillus aurantiacus tingitanus*, *B. mesentericus niger* Lunt, and *B. lactis niger* Gorini. The effects of varying amounts of iron, manganese, and copper are also studied. As might be expected, growth and pigmentation are very greatly affected by the constituents in the media. The results are too extensive and detailed to be adequately summarized in the present review. They will mainly be of interest to those microbiologists who are interested in the specific effects of certain factors upon bacterial life.

In Part II, it is reported that Roentgen rays destroy *B. aurantiacus tingitanus* rather readily, but that much heavier radiation is required for killing *Saccharomyces cerevisiae* completely. With non-fatal irradiation of the yeast, the formation of mutant colonies (as previously reported by Nadson), was never observed.

Portions of this thesis have been incorporated in some of the separate papers in fascicules XIII and XIV of the annual publication *Travaux du Laboratoire de Microbiologie de la Faculté de Pharmacie de Nancy* (reviewed in this journal, 20: 294 and 21: 203). In both parts I and II, the data are carefully tabulated and are discussed in detail, in comparison with the work of previous investigators along similar lines. Many references are given.

WALTER C. TOBIE

MICROBES OF MERIT.

By Otto Rahn. The Jaques Cattell Press, Lancaster. $4.00. viii + 277 pp. + 1 plate. 1945.

In writing about *Microbes of Merit*, Otto Rahn has produced a book of merit equal to his subject. In shifting attention from the pathogens to the great variety of saprophytic bacteria, molds, and yeasts, he accomplishes what has been all too infrequent in texts and courses of general bacteriology. While it is written in popular style for the layman, biologists will find that *Microbes of Merit* is well worth reading, and it should find a valuable place on the shelf of books for supplementary reading in general biology or bacteriology.

Rahn first discusses the sizes of bacteria, in a chapter beautifully illustrated with photomicrographs of shadowed organisms and electron microscope photographs. A history of the discovery of bacteria is then followed by an account of the nutrients utilized by microorganisms, and of their metabolism, reproduction and spore formation. Contamination and techniques for the isolation and maintenance of pure lines derived from single cells are described in some detail. Then interrelations of microbes, including their production of antibiotic substances, are taken up. This leads to the nitrogen cycle and the role of bacteria in keeping phosphorus and sulfur in circulation. Other topics include: sewage disposal; the maintenance of soil fertility; the use of yeasts in wine-making, brewing, industrial alcohol manufacture, baking, and other processes; food spoilage and preservation; the action of bacteria in making sauerkraut, pickles, silage, buttermilk and lactic acid, cheese, vinegar and acetic acid, propionic acid, citric acid, acetone and butyl alcohol, glycerine, enzyme preparations, and many other useful substances; microbes as human food; the dependence of higher organisms on symbiotic bacteria in their intestines for the absorption or synthesis of vitamins; and the use of microorganisms in assays of vitamins, amino acids, sugars, and other substances. The mere listing of these topics is a sufficient index to the richness of the subject surveyed by Rahn.

The book is well printed and excellently illustrated throughout, and is supplied with an index. Its sole flaw seems to be due to a failure of the editor to alter the occasional misspellings and tell-tale casts of language that indicate the author's foreign origin.

BENTLEY GLASS

DISINFECTION AND STERILIZATION. *Second edition.*

By Ernest C. McCulloch. Lea & Febiger, Philadelphia. $6.50. 472 pp. 1945.

There have been many outstanding contributions and developments in this field since the first edition of this work appeared. This edition has been completely revised and much new material added. There are detailed discussions on the various sulfonamides and a brief but pertinent summary of our knowledge of the antibiotics. The latest information on the various disinfectants and the proposed methods of evaluating them are given. Water purification, sewage treatment, and air disinfection are adequately covered. There are chapters on the germicidal properties of the body fluids and secretions, and on the natural agencies which control microbial populations. This book brings together, in very usable form, a great deal of material previously available only in the original articles scattered through the literature. It is a reference book for bacteriologists, sanitarians, and members of the medical profession. It will be useful for teachers and students in these fields. There is a good index.

ELIZABETH PETRAN

HEALTH AND DISEASE

MEDICAL DISEASES OF WAR.

By Sir Arthur Hurst with the cooperation of H. W. Barber, H. B. F. Dixon, E. H. R. Harries, F. A. Knott, Melville D. Mackenzie, T. A. Ross, Arnold W. Stott. William Wood, Williams & Wilkins Company, Baltimore. $6.00. viii + 511 pp.; 8 plates. 1944.

The author of this generally recognized work on military medicine is primarily a neurologist. Possibly for this reason, the first seventeen chapters, or almost half, of this compactly written volume, deal with the neurological diseases of war. This section of the book in particular reflects a rich and varied personal contact which Col. Hurst had with military medicine in the field during the First World War.

This is not a text book in the strict sense. No attempt is made to consider all diseases of war in all theatres of military operation. Instead, the author limits his discussion for the most part to those clinical conditions which the British met during the First World War, the post-war period, and to a limited extent, during the early phases of the Second World War. Certain sections of the book, including those on infective jaundice, infective hepatitis, sections on

sciatica and the treatment of bacillary dysentery, have been entirely rewritten since the previous edition. Alterations and additions in light of recent medical developments have been instituted in various other sections of the book, particularly in those dealing with digestive disorders, malaria, and tetanus.

One admirable feature of this monograph is the author's historical review of each disease entity considered. Short but remarkably colorful, these discussions in retrospect lend much to the realization of the part which each of these diseases has played in the fortunes of war around the globe during recent centuries. The chapters on trench fever and louse-borne typhus are especially interesting. Col. Hurst has obviously had first-hand experience with this malady, which caused the loss of so many man-hours of duty during the First World War. Concerning the etiologic agent, the impression is left that it is virtually accepted that the organism in question is a variety of *Rickettsia*. While this may eventually be definitely shown, more prominence might well have been given to the continued presence of doubt. If *R. quintana*, the supposed etiologic agent, develops as a lumen parasite of the louse's gut, the definition of the rickettsial group will require revision to include this extracellular organism. Mackenzie's presentation of louseborne typhus is accompanied by a full-page map showing the distribution of the various types of typhus in the Eastern Hemisphere as well as by several graphs dealing with the endemicity of the disease.

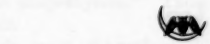
There are three chapters on enteric infections. The discussion of the bacteriological diagnosis of typhoid and paratyphoid fevers and the bacillary dysenteries by Knott, of Guy's Hospital, London, are exceptionally clear and complete. The chemo-therapeutic course suggested for uncomplicated amebiasis seems overly drastic when considered in light of the American respect for the toxicity of emetine hydrochloride. Its immediate use upon finding cysts of *Endamoeba histolytica* in the absence of any dysentery or other dramatic symptomatology would find many to doubt the advisability of such a procedure, particularly since other equally efficacious and less toxic drugs are available. Amebic hepatitis, hepatic abscess, both chronic and acute, are discussed fully. Diagnosis of hepatic abscess is described as being based entirely on symptomatology and confirmation by emetine treatment. Mention might have been made of examination of pus aspirated from the abscess and the use of modern cultivation techniques on such material.

Col. Dixon's consideration of the military problem of malaria is brief but covers the pertinent phases of malariology in the field. More than half of this section deals with treatment, at the expense of the discussion of the clinical symptomatology and other topics. The section on malaria control might have been improved by including a consideration of the more modern methods of larvicidal techniques and other late developments in field malaria control.

There are excellent chapters on meningicoccal fever and diphtheria covered by Maj. Stott and by Harries respectively. Hurst's treatment of the subject of tetanus on the battle field is vitally interesting. Some truly remarkable comparisons are brought out on the morbidity and mortality reports from the two world wars. The chapter on skin diseases includes a timely discussion of the dermatophytoses as well as an able review of the more common cutaneous infections. A short consideration of the war gases and their effects concludes the book.

The book as a whole is more readable than many American works which cover the material perhaps more fully but not always more effectively. This is due in part to the inclusion of innumerable case histories, personal observations, and opinions of the senior author and his colleagues. If the volume presents some seemingly obvious omissions, one must remember that in writing on the diseases of a global war, one must draw the line somewhere. It would seem that Col. Hurst has done this with admirable judgment.

ALAN C. PIPKIN



PATHOLOGY OF TROPICAL DISEASES. *An Atlas. By J. E. Ash and Sophie Spitz. W. B. Saunders Company, Philadelphia.* $8.00. x + 350 pp. 1945.

Those individuals who are interested in tropical diseases are indebted to Ash and Spitz for compiling the present helpful book. As director and pathologist, respectively, of the Army Institute of Pathology, they are in an excellent position to draw upon one of the richest collections of pathological specimens in the world, the Army Medical Museum. With the growing emphasis upon tropical diseases, the appearance of a book devoted primarily to their pathology is indeed timely. The book covers a wide variety of etiological agents, as the excellent table of contents clearly indicates. However, the authors do not claim to present an exhaustive list of diseases that occur in the tropics but deal primarily with those which they have had the opportunity to study. Perhaps that is one of the major reasons for the impressive, authoritative nature of the book.

Those diseases are emphasized that "have proved to be of greatest importance from a military standpoint and that are likely to be of importance to the civilian profession." As a consequence, the greatest number of pages is devoted to malaria, filariasis, scrub typhus, schistosomiasis, bacillary and amebic dysentery, plague, leprosy, and fungus diseases.

As the sub-title indicates, the book is really an atlas devoting the majority of space to a graphic presentation of the subject of tropical medicine. There are,

in all, 941 illustrations consisting of photographs of gross pathological specimens, photomicrographs of tissue sections and various other preparations for microscopic study, photographs and x-ray pictures of patients with clinical manifestations of the diseases, diagrams of the life cycles of parasites, and world maps demonstrating the geographical distribution of the diseases. Inserted on the maps are drawings of the arthropod vectors of the diseases represented. Fifteen of the illustrations of malaria and leprosy are in full color. As might be expected, relatively little space is devoted to the written text, actually only 80 of the 350 pages of the book. Some of the diseases or parasites are not discussed at all, but the life cycles of the organisms are presented in easily interpreted diagrams. The quality of the text material more than compensates for any quantitative deficiency, as the essential facts of the pathology are presented in a clear, concise, and readable style. In addition to the pathological discussion, enough background information is included to enable the reader to obtain a well-rounded picture of the disease, its etiological agent, and its importance.

M. M. BROOKE

A TEXT-BOOK OF ORAL PATHOLOGY. *Third Edition. By Thomas J. Hill. Lea & Febiger, Philadelphia.* $6.50. 407 pp. 1945.

This medium-sized text-book presents very adequately and concisely the nature and significance of the many malformations and diseases occurring in the oral cavity of man and contains much information not to be found in works on general pathology. The following general topics are dealt with in particular and at length: Abnormalities of development of the oral tissues, specific pathological processes in the dental and periodontal structures, and specific and non-specific pathological processes of the facial bones and soft tissues of the oral cavity. In the introduction, the fact is stressed that our empirical standard of normality of dentomaxillary development is rarely attained by modern, civilized man. If we admit that normality can undergo evolutionary change and that our concept of "normality" should really be determined by the prevalence of a condition, "we then accept the irregular, the asymmetric and the imperfect as our standard of normality." By regarding as pathological everything that deviates from the normal and by accepting the rare ideal as the standard of the human dental apparatus, this work has a wealth of pathological conditions to discuss.

S. W. Chase, B. E. Lischer and E. Reiter, besides the chief author and the former co-author, R. W. Bunting, have collaborated in the production of this scholarly volume which, though intended primarily for dentists and as an aid in teaching dentistry, should be in every medical library. The new, third edition has been conscientiously revised and somewhat enlarged. It contains selected bibliographies, including the most recent literature, and 332 instructive and well reproduced illustrations. The subject index is all too brief.

A. H. SCHULTZ

ESSENTIALS OF BODY MECHANICS IN HEALTH AND DISEASE. *Fourth Edition. Lippincott Essential Series.*

By Joel E. Goldthwait, Lloyd T. Brown, Loring T. Swaim, and John G. Kuhns, with a chapter on "The Heart and Circulation as Related to Body Mechanics" by William J. Kerr. J. B. Lippincott Company, Philadelphia. $5.00. xiv + 337 pp. 1945.

This book is one of a series of concisely written manuals intended primarily for the general practitioner. Its presentation is thus that of a handbook rather than that of a text. The problem of body mechanics is essentially one of correct posture, involving the relationship of parts of the body so that a minimum amount of strain is present. The authors are fully cognizant of the importance of individual variation, and have grouped the variations into three body types—slender, stocky, and average or normal. Definition of the types is based on the structure of viscera as well as on that of the skeletal and muscular systems. Various syndromes, in which basic deformities of body mechanics are involved, are described, and corrective exercises and mechanical supports are recommended. Interest in the subject, apart from its clinical significance, lies in its recognition of the importance of body constitution in medicine. Relatively neglected in the clinic, the study of body mechanics is a logical and scientific approach to the concept of good health. The authors should be commended not only for the success of their presentation, but for their point of view.

JAMES M. SPRAGUE

THE STORY BEHIND GREAT MEDICAL DISCOVERIES. *By Elizabeth Rider Montgomery. Drawings by Vartanian. Robert M. McBride and Company, New York.* $2.00. 247 pp. 1945.

This is another one of these "popular" books on the history of medicine. In little sketches, mostly consisting of dialogues, 43 major medical discoveries from William Harvey to Sir Alexander Fleming are "described." There seems to be little point in criticising in detail such products. People who read, and authors who write such books don't read or heed scientific book reviews. People who read book reviews don't read such books anyhow.

ERWIN H. ACKERKNECHT

DR. MORTON: *Pioneer in the Use of Ether.*

By Rachel Baker. Illustrated by Lawrence Dresser. Julian Messner, New York. $2.50. 224 pp. 1946.

It is fitting and proper that during the centenary celebration of the first administration of ether, there should appear biographies of Dr. William Thomas Green Morton. The biography written by Miss Baker is a fascinating one. Her style is lucid and the human side of Morton's life engrosses and captivates the reader.

The author traces young Morton as an embryonic medical student and dental student, through his love-affair with beautiful Elizabeth Whitman, to the time when he became a commercial dentist in the city of Boston, and then developed the idea that "he had a great motive to destroy or alleviate pain."

His first experiences with ether, in the chemical laboratory of Dr. Jackson, are given in great detail. The first administration of ether to Mr. Abbott in the Massachusetts General Hospital on October 16, 1846, is developed with all of the drama and solemnity which accompanied that occasion. One feels that he stands under the "ether dome" in that hospital when Dr. Warren looks to Dr. Morton and Dr. Morton looks to Dr. Warren and says, "Dr. Warren, your patient is now ready."

The trials and vicissitudes of Morton, the benefactor, are given in detail after the discovery of ether. His unending controversy with Jackson and the participation of Dr. Wells in the conflict, makes one live again through the "ether war."

The entering of Crawford W. Long into the story and the gradual decline of Morton's fight for his rights, are told most interestingly. The last years of Morton's life, when he sought only peace and then left the farm at Etherton to administer ether to the soldiers on the battlefield of the Civil War, are described in a most captivating manner.

The reviewer wishes to commend the book to those who are interested in the field of anesthesia and in the difficulties experienced by a pioneer.

JOHN C. KRANTZ, JR.

MAN AGAINST PAIN. *The Epic of Anesthesia.*

By Howard Riley Raper. Prentice-Hall, New York. $3.50. x + 337 pp. + 24 plates. 1945.

This timely account of the history of anesthesia, written by a dentist who has devoted his life to the study of the history of anesthesia, is divided into four parts. The first is concerned with the background of anesthesia; the second includes the discovery of anesthesia, with an interesting account of the personalities of the discoverers; the third deals with the story of human conflict among the various discoverers of anesthesia; and part four is concerned with the progress of modern anesthesia, and what the medical profession and public may expect from this realm of endeavor in the years to come. In addition, there is a section of illustrations depicting monuments, memorials, and photographs of the discoverers of anesthesia; and finally, there is an excellent critical bibliography of other work in this same field.

Raper has developed a lucid style in explaining the conditions in the surgical amphitheater prior to anesthesia. The dramatic episode of the giving of ether for the first time, in the Massachusetts General Hospital, is depicted most graphically. Characters of the various workers in the early field of anesthesia are delineated with great craftsmanship. The author shows his skill as a discriminating historian in his statements with regard to the place of Henry Hickman in the field of anesthesia when he contends that Henry Hickman had "the idea without the accomplishment of the result," whereas Crawford W. Long "achieved the result without conceiving of the splendor of the idea," and later the author states that "Genius is largely a perception of significance."

The reviewer regrets that certain statements with regard to modern anesthesia and anesthetic agents are not exactly in accordance with fact, such as the statement on page 200 "that cyprome ether later was identified as propethylene." These are two distinct compounds.

In the main, the author fulfills his purpose in bringing to the lay reader, dentist, and physician, an excellent and captivating account of one of mankind's greatest achievements—the discovery of anesthesia.

JOHN C. KRANTZ, JR.

VD MANUAL FOR TEACHERS.

By Samuel D. Allison and June Johnson in collaboration with W. Tate Robinson and Elmer J. Anderson. Emerson Books, New York. $2.00. 149 pp. 1946.

This manual, an adaptation of one developed for use in the Territory of Hawaii, is well tailored to fit its purpose—a guide for secondary school teachers for instruction regarding venereal diseases. The book first deals with the need for education in this subject and the present state of instruction in the U. S. A. program is suggested. The rest of the manual is in a form suitable for direct application in teaching.

The second section contains information regarding the venereal diseases. Much of it is given in outline form. This particular part might have been longer, so that more data could have been incorporated. However, it may be more practical and less confusing to the not-too-well-informed teacher that the material has been kept brief and compact. Certainly the essentials are included and references are ample. This middle section should also be especially good for reference use in libraries.

The last part contains lists of basic questions and descriptions of good available films, other visual aids,

and some transcriptions. There are even some tests, all ready-made for the classroom.

Thus this small volume is to be recommended as a constructive, intelligent and welcome contribution in the field of public health education. Because of its excellence, it is to be hoped that it will be rewritten from time to time as events and changes may warrant.

HARRIETTE D. VERA

A. A. A. S. RESEARCH CONFERENCE ON CANCER. *A Conference of Papers and Discussions Presented at the Summer Meeting of the Section on Chemistry of the American Association for the Advancement of Science at Gibson Island, Maryland, July 31–August 4, 1944. Edited by Forest Ray Moulton. American Association for the Advancement of Science, Washington, D. C.* To members, $4.00; to non-members, $4.50. 333 pp. + 2 plates. 1945.

Each summer since 1938 the A. A. A. S. has sponsored a series of research conferences at Gibson Island. The meetings have included a variety of subjects, but it was not until 1944 that a full week's conference was given over to aspects of cancer. The present monograph is a compilation of the talks and discussion presented at the Cancer Conference in 1944 and in a sense is a landmark that records in some measure the status of cancer research in 1944, much as the earlier A. A. A. S. monograph, *Some Fundamental Aspects of the Cancer Problem*, did in 1936, in covering the symposium on cancer sponsored by the Section on Medical Sciences at the Atlantic City meeting of that year.

The monograph consists of thirty separate papers classified under five separate headings: the Virus approach, Carcinogenesis, Enzymes, Diet, and Chemotherapy. It is obvious that none of these subjects could receive detailed scrutiny in such abbreviated form; nonetheless, the reviewer is not aware of any other source whereby the reader may obtain so much information in the field of cancer research in so little space. The reader is warned that much of the information is predigested for him, but an adequate bibliography is appended to each article which will enable him to consult the original literature and judge for himself.

The virus approach to the cancer problem is the most completely discussed of any of the subjects in the monograph, and ten separate articles are devoted to it. The first article by F. Duran-Reynals and E. W. Shrigley is recommended to those who wish a general review of the whole problem of the relationship of viruses to cancer. These authors enumerate reasons which suggest viruses as the causal agents of neoplasms, and they leave little doubt as to their adherence to the virus theory of cancer formation. As borne out in the discussion of the paper, there were those who disagree with any attempt to relate the cause of cancer to one all-inclusive theory by a "process of analogies and highly theoretical considerations." Nevertheless, the proponents of the virus theory are slowly continuing to obtain the additional data which bolsters their position.

For those interested in the subject of the milk influence or factor, and its relationship to the etiology of mammary cancer in mice, the reviewer urges them to study the article on this subject by J. J. Bittner. Bittner is a master in this field, and his review, together with one on the properties and nature of the milk agent by M. S. Shimkin and H. B. Andervont, summarizes what was known in this field up to 1941.

It has long been known that certain viruses can be propagated in chicken embryos, and Alfred Taylor of Texas describes his efforts to obtain a virus from certain mammalian tumors with the aid of this technique. Although his first efforts appeared to be fruitful, attempts to repeat the experiment have unfortunately been unsuccessful. One of the purposes of the Gibson Island Conferences has been an effort to stimulate advances in the difficult frontier fields by thorough discussion of the subject, and in this sense, Taylor's paper was adequately discussed and additional negative data presented by W. R. Bryan, H. Kahler, and V. T. Riley of the National Cancer Institute, F. R. Heilman of the Mayo Clinic, and G. H. Twombly of the College of Physicians and Surgeons in New York. In spite of the general failure to demonstrate virus production of mammalian tumors by this method, much credit is due Taylor for re-introducing a new method for the propagation of mammalian tumors in the laboratory.

The second section of the book deals with the role of various factors in carcinogenesis. An article by L. F. Fieser lists various possible correlations of reactivity and structure of the hydrocarbons and their possible relationship to cancer formation. The correlations are based on reactions observed in the test tube, and no definite conclusion can be obtained from them as to the mechanism of carcinogenesis. Another chapter in this section is by W. R. Earle, who presents his classical work on the "Production of Malignancy *in Vitro*." He describes how fibroblasts originally obtained from the muscle wall of C3H mice became malignant when grown in tissue culture in the presence of methylcholanthrene. However, certain control fibroblasts to which no hydrocarbon had been added also changed into neoplastic cells. Much work remains to be done on this problem, and for a more complete story the reader is referred to a series of articles by Earle in the *Journal of the National Cancer Institute*, 4: 131–248, 1943.

Although a considerable amount of work was presented at the Conference by H. S. N. Greene, his work is summarized in the monograph in abstract form. As the result of his studies on the transplantation of tissues into the anterior chamber of the eye, he concludes that "cancers are not simply local tissue diseases but instead represent local manifestations of a general-

ized constitutional disorder, and second that a primary neoplastic focus is not a cancer and that before becoming a cancer it must undergo a process of progressive evolutionary development."

The third section of the book contains five chapters on enzymes and tumors. For an excellent summary and review of our knowledge concerning the content of certain enzymes in normal and neoplastic animal tissues, the reader is encouraged to study the chapter by J. P. Greenstein. This is an excellent review of the subject in which he makes ten generalizations on the enzyme pattern in these tissues.

C. J. Kensler and C. P. Rhoads have a chapter in which they postulate a possible mechanism of carcinogenesis with the azo dye p-dimethylamino-azobenzene. They suggest that it is not the whole compound itself that is the true carcinogen, but a cleavage product, unsymmetrical, or N,N-dimethyl-p-phenylene diamine, or its free radical, which functions as an enzyme poison. However, as pointed out in a later chapter by H. P. Rusch *et al.*, the evidence for such a theory is far from conclusive.

Those interested in the distribution of enzymatic activities in various fractions of mammalian liver or in the serology of cathepsins are referred to the papers by Albert Claude and M. E. Maver and J. W. Thompson.

The fourth section of the monograph is devoted to some of the aspects of diet and its relationship to cancer. A chapter by R. J. Williams is recommended to those who desire a reference on the content of the B-vitamins in normal and neoplastic tissue. Perhaps of greatest interest is the fact that cancer tissue, regardless of the tissue or animal of origin, is biochemically a *type of tissue* that is more uniform in its vitamin "spectrum" than are various normal but different tissues obtained from the same animal. For a more complete review of this subject the reader is referred to the University of Texas Publication number 4237, published in 1942.

An article by H. P. Rusch, C. A. Baumann, J. A. Miller, and B. E. Kline on "Experimental Liver Tumors" is in the nature of a review. In it is discussed the means of inducing hepatic tumors, the effect of diet on tumor formation, the fate of the azo dyes in the body, and the relationship of diet and liver cancer in humans. The most carcinogenic of all azo dyes thus far tested, m′-methyl-p-dimethylaminoazobenzene is listed along with other related azo dyes. This article is the most recent review article on the subject of experimental liver tumors, and should be studied by anyone wishing to obtain a background in this field. The only other review on this subject was prepared in 1937 by Kinosita and has been translated into English, but copies of it are no longer available.

The fifth and last section of the monograph is devoted to chemotherapy. C. M. Flory has reviewed the effects of therapeutic agents on human and mouse leukemia and has included many of the methods attempted. This article is recommended to those interested in leukemia. In an article entitled "The Effect of Various Agents on Normal and Malignant Tissues," H. O. Singher, C. J. Kensler, and C. P. Rhoads describe a method of testing compounds on the tumors implanted into fertile chicken eggs. This method can be used as a screening test in the search for tumor inhibitors. The last four articles in the monograph describe unsuccessful attempts to inhibit the growth of tissue cultures with penicillin. A discussion follows each chapter and the stimulating tenor of these is quite evident.

H. P. RUSCH

HEALTH CARE OF THE FAMILY.

By Ramona L. Todd and Ruth B. Freeman. W. B. Saunders Company, Philadelphia and London. $3.00. vi + 530 pp. 1946.

This "textbook on family health conservation" is organized into four parts: environment and prevention of disease, reproduction, individual health care, and home care of illness. The first section covers a great variety of subjects, including sanitation, health hazards, and infectious diseases, all of which are dealt with in an elementary and superficial manner—possibly more suitable for adult education or high school classes than for college students. In the discussion of reproduction, physiology, pregnancy, childbirth (and bed rest) are considered. This is followed by chapters on infants, children, and adults. Fully a third of the book is devoted to home nursing—mainly lists of directions which appear to be clear, simple and practical. Additional readings are listed at the end of each chapter. There are a glossary of terms and an index.

HARRIETTE D. VERA

A FUTURE FOR PREVENTIVE MEDICINE. *Studies of The New York Academy of Medicine Committee on Medicine and the Changing Order.*

By Edward J. Stieglitz. The Commonwealth Fund, New York. $1.00. xvii + 77 pp. 1945.

During the last fifty years preventive medicine has been extremely successful in fighting the acute infectious diseases and in protecting the young, as is clearly reflected in our vital statistics by the great changes in mortality and morbidity. The author shows that these very successes have created new problems, and that we now have to broaden our concepts of preventive medicine. Chronic, degenerative diseases are now our main hazards. The old preventive medicine, influencing mainly the environment (by quarantine, sewerage, milk and water supply control, etc.), has to be completed by an extension to the individual. Not only the provoking, but the predisposing and perpetuating causative factors have to be considered. Regular

"health inventories" are necessary. "Control therapy" has to avoid at least disability in the chronic, degenerative diseases. We need in addition to curative a "constructive" medicine for the improvement of health (which to the author is identical with happiness). New types of education and research are required.

This is the third volume in its series. Though still shorter than its excellent companion volumes, previously reviewed in this journal (QRB: 20: 291 and 21: 115), it gives a convenient summary of the situation. Unlike its predecessors it does not include historical material. Where it touches upon more general problems such as the attitude of primitives towards disease or the "survival of the fittest," it shows little familiarity with the more modern results of research. How the author intends to carry out his blue print of a new preventive medicine on a mass basis, while being violently opposed to government-sponsored "health programs," remains his secret.

ERWIN H. ACKERKNECHT

DOCTORS, DRUGS AND STEEL.

By Edward Podolsky. The Beechhurst Press, Bernard Ackerman, New York. $3.75. 384 pp. + 15 plates. 1946.

Today, in peace, there is increasing technical progress in all fields. Podolsky has given us a resumé of the latest progress science and medicine have made to insure better health and longer life for all.

This book is divided into eleven sections, each treating its subject-matter in a broad survey and complete in itself. The sections are entitled: The Heart Menders; Healers of the Brain; The Mind and The Nerves; The Lame, The Halt and The Blind; The Four Scourges; The Breath of Life; The Story of Childbirth; Miracles with Blood; The War on Poisons and Bacteria; Doctor Nature; New Methods of Detecting Disease; and The March of Medicine.

The layman, unaware of many of the latest medical achievements, will marvel at them and their almost immediate and wide-spread practicability. New and improved drugs have come into prominence. The treatments of insanity, tuberculosis, and leprosy have all benefitted by the newly found drugs. The healing "steel" of the surgeon's knife has given relief to sufferers of heart disease, high-blood pressure, and other ailments of our fast-paced civilization. In instances the blind can be made to see, the deaf to hear, and the dumb to talk. Painless childbirth has grown into a science. Cancer is still incurable, but by-products of the atom bomb have yielded artificially radioactive elements which are proving of valuable aid in the discovery of a cure for this dread disease. Also science and medicine continue to search for the undiscovered "Magic elixir" of life—Ponce de Leon's "Fountain of Youth."

Podolsky continues to produce medical writing of outstanding merit in this latest volume. The layman will find much of interest here, presented in terms that he can comprehend. Doctors and biologists will not be so fortunate. The lack of a bibliography is a marked defect. Notwithstanding this drawback, the gratitude of layman, biologists, and physicians for so competent a survey will be great.

E. H. HERRON

MEDICINE IN INDUSTRY. *Studies of the New York Academy of Medicine, Committee on Medicine and the Changing Order.*

By Bernhard J. Stern. The Commonwealth Fund, New York. $1.50. xv + 209 pp. 1946.

The effects of industrialization on health have been tremendous. Some of these are, for example, the exposure to hazards new in kind or degree, the improvement in standards of living, the slow recognition of the association of protective or preventive services with the promotion of efficiency, the changing role of the industrial physician, and the gradual increase in the scope and availability of medical care.

The extent and labile nature of the problems of health in relation to industry are here appraised in the light of scientific, social, and legislative developments. The amount of disability and the difficulties in evaluating inadequate information are clearly set forth. The particular problem of the small plants is discussed, along with the influences of sex, age, low income, physical handicaps, variation in state compensation laws, and criteria for the selection or rejection of employees. Evidence is presented that the types of health services and health insurance which have recently developed offer a measure of protection to only a negligible percentage of the population. The discrepancy between knowledge and application in the interest of public welfare is brought out. With better understanding and better collaboration between labor, employers, medical profession, and governmental agencies, industrial medicine could assume its rightful place in the promotion of public health.

HARRIETTE D. VERA

DOCTORS EAST, DOCTORS WEST: *An American Physician's Life in China.*

By Edward H. Hume. W. W. Norton & Company, New York. $3.00. 278 pp. + 13 plates. 1946.

This is the story of an American doctor in China. It begins in 1905, when Edward Hume, descendant of two generations of missionaries in India, was called to found a medical center in the isolated capital of Hunan province, the great city of Changsha. The result of his years of effort was the great medical school of Yale-in-

China. Not a formal autobiography, the book takes the form of a delightful series of sketches, vividly related by a man of sharp but sympathetic vision. One sees the Chinese city, the excitement of the opening of the first dispensary, the slow fruition of unceasing efforts to win the confidence and respect of the people. During the first two years after the hospital was opened, the dying had to be sent home, as a death on the premises would have turned the people against the foreigners. It was indeed true, as one of the Chinese proverbs which grace the beginning of each chapter puts it, that: Capturing the city is secondary, capturing the heart is primary.

Among the most interesting aspects of the young doctor's foreign education was his gradual recognition that the traditional Chinese doctors were often great diagnosticians, heirs of a science going directly back to such great physicians as Wang Shu-ho, authority on the pulse, and Chang Chung-ching, who wrote a description of typhoid fever about A. D. 196 that Hume compares in excellence with that of Osler, under whom he had studied at Johns Hopkins Medical School. The native pharmacopeia, too, in spite of its many strange ingredients, turned out to include such effective drugs as ephedrine, crow's liver (used for pernicious anemia), and seaweed extracts (used for goiter). As mutual respect increased, the hospital thrived, and the medical school was opened. Hume became a real leader in the development of medical science in China.

The story of these achievements blends with the drama of Chinese daily life and of the stormy days of revolution, banditry, and rival war-lords, when often the work was in peril yet somehow always came through unharmed. Finally, in 1928, the medical school became a national institution, and, as had been planned from the first, the trained Chinese colleagues took over its direction. Edward Hume's Chinese motto for the book reads: The way is one, the winds blow together. Another person might equally well have chosen that from one of the chapter headings: If you plant for a year, plant grain; if you plant for ten years, plant trees; if you plant for a hundred years, plant men.

This is the second book to receive the Norton Medical Award for books on medicine and the medical profession written for laymen. It will very likely be a long time before an equally fine choice can be made.

BENTLEY GLASS

PSYCHOLOGY AND ANIMAL BEHAVIOR

PERSONALITY IN ARTERIAL HYPERTENSION. *Psychosomatic Medicine Monographs.*

By C. A. L. Binger, N. W. Ackerman, A. E. Cohn, H. A. Schroeder, and J. M. Steele. The American Society for Research in Psychosomatic Problems, New York. $3.00. 228 pp. 1945.

This monograph is a carefully documented scientific study. Correspondingly, the bulk of the volume, 193 pages out of a total of 228, is occupied by twenty-four case histories of persons suffering from arterial hypertension. These twenty-four patients were selected from among cases undergoing treatment in the Hospital of The Rockefeller Institute for Medical Research on the basis of age and absence of pronounced arteriosclerotic changes, but with no effort to choose or to eliminate those who exhibited manifest "nervous" disturbances. The patients were then studied in psychiatric interviews, and one in psychoanalysis, for personality organization and evidence of any disturbance of personality. The material thus obtained was all subjective. This material was then arranged chronologically and interpreted, with special attention to concealed and unconscious motivations. This and a resumé of the clinical facts constitute the case histories as presented.

Inferences from this material, conservatively drawn, make up a final 25 pages. In brief, all twenty-four subjects of the study presented evidence of emotional disturbance which has been designated "neurotic," and which in most instances long antedated the development of hypertension. The outstanding feature was an early sense of insecurity, but with great variety in the early environmental influences which might be held accountable for this. Consistently the patients showed the following tendencies: exaggerated dependent strivings, submissiveness coupled with stubbornness, feelings of weakness and defenselessness, suppression of hostility, fear of injury and emotional detachment, and a tendency to develop acute emotional disorders with anxiety, depression, and disorganization. These translate into characteristic and recurring difficulties in interpersonal relations. In a large proportion of cases the onset of hypertension can be related to such an acute emotional crisis.

In a final paragraph the authors' approach to the study is made most clear in a refusal to draw conclusions as to the causation of hypertension from the evidence presented. The monograph stands as a highly suggestive mass of evidence, a valuable building stone in a greater understanding of psychosomatic relationships.

SARAH S. TOWER

THE PSYCHOLOGY OF ATTENTION.

By T. A. Ribot. The Marcel Rodd Company, Hollywood and New York. $2.50. vi + 78 pp. 1946.

For reasons that are very difficult to understand, the publishers of this volume have seen fit to re-issue an essay on the *Psychology of Attention* which was originally published nearly sixty years ago and was first translated into English in 1890. The publishers print a preface by an instructor in one of the eye exercise

schools, and the inspiration for a new edition was apparently her belief that Ribot's ideas about attention are important for this form of visual instruction.

Most psychologists are already familiar with Ribot's views, and non-psychologists will find little if any real value in reading this so-called classic. In its day, the work possessed some importance, but it has now only historical interest.

W. C. H. PRENTICE

HUMAN NATURE IN THE MAKING.

By Max Schoen. D. Van Nostrand Company, New York. $3.25. viii + 298 pp.; 6 plates. 1945.

Schoen has tried to write a simple book about the development of human personality so that the lay reader may grasp the importance of scientific psychology in understanding the more complex social issues that concern such readers. Like so many other attempts, this one is largely a failure. The selections which present basic scientific findings are too few and too scattered to justify their existence. The rest of the book is an intelligent but wordy discussion of how psychology and society are connected. As is so often the case, that discussion will certainly fail to satisfy psychologically trained readers. But then the book was not written for such readers. It is reasonable to suppose that high school students or other readers of equivalent educational background will find this a valuable work. It is unlikely that more advanced students will profit much from it, since there are so many other books which do the same thing better.

W. C. H. PRENTICE

ADOLESCENCE AND YOUTH. *The Process of Maturing. By Paul H. Landis. McGraw-Hill Book Company, New York and London.* $3.75. xiii + 470 pp. 1945.

"In the study of adolescence there has been too much emphasis on the physiological, too little on the social and psychological; too little understanding that experience is more than a function of physical maturation and inherent disposition; too little understanding of the impingement of the social processes on the developing organism. . . ." So states the author in his preface. He continues, "Adulthood in a complex society has little relationship to physiological maturity. It is rather defined in terms of moral, marital and economic competence—social criteria rather than physical."

The text is divided into five parts: I, Biological, Social Structure, and Personality; II, Attaining Moral Maturity; III, The Transition to Marital Adulthood; IV, The Struggle for Economic Adulthood; V, Adolescents and Youth in the School. These sections include 21 chapters written in a simple, interesting manner, sure to attract undergraduates and supply them with valuable information about problems uppermost in their minds. Illustrative case material and picturized frequency tables are abundantly and appropriately scattered throughout the volume. Many of the data indicate the external behavior and expressed attitudes of adolescents and are of the poll type.

Landis has presented a sociological approach to adolescent phenomena. He has more material than is usually presented about rural youth and moral and economic problems. The whole tone of the book is socially progressive. The book, however, is not a thoroughly comprehensive study of "the process of maturing." It is a surface approach to adolescence; the deeper motivational trends, intra-personal relationships and integrative activities are scantily treated. The words "psychological," "learning," or "endocrine," for example, are not found in the index. The discussion of the "only child" does not contain any primary reference to the vast literature. In fact, there is a general dearth of references to sources in the biological and particularly in the psychological periodicals. A more precisely descriptive sub-title than "The Process of Maturing" would be "A Sociological Approach."

The chapter on personality is an especially inadequate discussion of these complex phenomena. Temperament is regarded as synonymous with introversion and extroversion; and a discussion of traits is limited to "five basic traits." Although the chapter heading contains the phrase "organic foundations," personality is defined only from a social standpoint and there is no reference to organic foundations, established individual traits, or developmental patterns, nor is there a reference in the bibliography to suggest that there may be any literature on this aspect of personality.

This text represents one of the major inadequacies of higher education in the era of specialization of the 1920's and 30's—a trend which tends to persist in many institutions. Complex phenomena are presented segmentally and by implication often as a total adequate approach. Frequently, as in the case of this text, the subject matter is well treated tangentially, but does not give the student a comprehension of the complexity and the multiphasic aspects of the problems studied. Landis is correct in his insistence that the social aspects of maturing have in some writings been minimized, but a remedy for that consists in its emphasis along with appropriate discussion of advances in biological and psychological research, or a frank statement regarding the limitation of his contribution.

FRED MCKINNEY

WHEN YOU MARRY.

By Evelyn Millis Duvall and Reuben Hill. D. C. Heath and Company, Boston. $2.40. xiv + 450 pp. 1945.

The authors of this book have fashioned it for wide use either in a formal college course or in meeting the problems raised in group discussions and in young family inquiry.

One of the authors is a biologist and the other, a sociologist. The basic orientation is sociological, but the objective findings in both the biological and sociological fields are emphasized. The authors attempt to furnish the reader with the kind of information necessary to become a good citizen and an adjusted individual. The volume includes discussion of problems provoked by the war era.

The book's four parts consider: "Anticipating Marriage," "What It Means To Be Married," "The Making of a Family," and "Family Life, Yesterday, Today and Tomorrow." Specific chapters include topics, as related to marriage, in this order: love, dating, courtship, engagement, morality, happiness, sex physiology, the honeymoon, marital conflicts, finances, crises, divorce, marital success, parenthood, religion, social changes, war, and the family of the future. The appendix includes Burgess and Cottrell's prediction scale, which is a check list with weighings showing the effect of various items of personal history on marital happiness. Included, also, is a list of various reliable marriage and family counseling services, by States.

The text is replete with learning aids: facetious cartoons, self-quizzes, charts, tables, listings, intriguing diagrams, and verbal examples. The style is highly readable and interesting. In fact, many a college textbook writer could learn much about the effective presentation of facts and principles from these authors. This stimulating presentation, however, is not attained at the expense of accuracy or technicality. There is a wide variety of factual material in the text, ranging from the cost of operating a car for one year to the biological consequences of negro and white mating.

There are fewer lengthy case studies than might be desirable in a book of this kind. Most of the references are to secondary sources, suggesting the authors attempted to make their contributions largely through the manner in which the material was presented rather than through emphasis on newer findings. There is no serious attempt at profound psychological analysis of the phenomena presented, but this is in line with the tradition in this field.

FRED MCKINNEY

SELF-CONSISTENCY: *A Theory of Personality.*

By Prescott Lecky. Island Press, New York. $2.50. 154 pp. 1945.

This series of essays on personality has been compiled by Lecky's friends since his death. It is apparently supposed to represent the theory of personality which the author had expected to publish in book form and on which he had already been working. Unfortunately, Lecky's literary remains seem to have been rather scanty, for his editors have found it impossible to produce so small a volume of 150 pages without repeating the same concepts and ideas, and even the same illustrations, two or three times.

As far as one can tell from these essays and addresses, Lecky had one main contribution to make to psychological theory. Like G. W. Allport, Lecky was impressed with the unity and integrity of human personality. He had no patience with approaches to the study of personality that emphasized diversity and disunity. His critique of Hartshorne and May, *Studies in Deceit*, is extraordinarily well done. It succeeds in establishing the basis of a general theory of personality merely by its thoroughness in negating the specificity theory.

It is very difficult to find much more than this one idea in the papers which Lecky's executors have published. The same notions, frequently stated in the same words, appear over and over again throughout these pages. The first chapter was well worth preserving. For the rest, it seems doubtful that psychologists will profit much from their publication.

W. C. H. PRENTICE

NEW DIRECTIONS IN PSYCHOLOGY: *Toward Individual Happiness and Social Progress.*

By Samuel Lowy. Introduction by Herbert Read. Emerson Books, Inc., New York. $3.00. xiv + 194 pp. 1945.

To the scientific reader, the title of this book is quite misleading. It has to do neither with "new directions" nor with "psychology." Writing in England in the midst of World War II, the author, a practicing psychoanalyst of many years' experience, looks at the maladjustment of human society, as seen in both war and peace, and asks how man might improve his society to bring about greater individual happiness and social harmony.

In a non-technical, popularizing style, the author draws upon the concepts of psychoanalysis in an attempt to assay what may be wrong in the relations of: children and parents, man and wife, sexuality and culture, the government and the citizen, religion and churches, and conservative and reformist movements. It is his principal conclusion that unconscious aggression is the root of our difficulties and that the cure for it is more love. In his concluding remarks, the author states the main idea of his book to be, "Do not let us rely, in the great cause of human happiness, on the voluntary fairness of people alone, if there be a way of intensifying, through a better-planned social process, this fairness of spirit in all interhuman relations."

Some laymen, who are unaware of the emotional bases of their social attitudes, may find this book help-

ful, but the biologist or psychologist can expect to find little in it concerning new directions in psychology.

CLIFFORD T. MORGAN

HOW TO KEEP A SOUND MIND. *Revised Edition of Keeping a Sound Mind.*

By John J. B. Morgan. The Macmillan Company, New York. $2.75. vii + 404 pp. 1946.

This volume is merely a revised edition of the book entitled *Keeping a Sound Mind* which was published twelve years ago. It is somewhat difficult to evaluate books of this sort when reviewing them for scientific journals. Morgan was a competent psychologist who was able, no doubt, to justify some if not all of his dicta by reference to clinical and experimental evidence. The fact remains, however, that he never does so in this book and that he gives the impression of supporting his rules about mental hygiene only by anecdotes concerning success in school and business. The entire volume might have been made up of selections from the *Reader's Digest*, and, as a matter of fact, fairly large portions of it actually did come from the old *American Magazine* in the days when it was the great success-story publication.

This book is no better and no worse than most of the popular personality books. It is, however, very disappointing as a product of laboratory psychology, and it cannot be recommended to scientific readers.

W. C. H. PRENTICE

THE PERSON IN THE BODY. *An Introduction to Psychosomatic Medicine.*

By Leland E. Hinsie. W. W. Norton and Company, New York. $2.75. 263 pp. 1945.

This is a very good statement of the principles of psychosomatic medicine, well written, with case material used in an illustrative, informal manner, showing clearly the psychogenic factors in neurotic and psychosomatic personal performance. It constitutes one of the more readable statements in this much publicized field and can be highly recommended to lay readers and general biologists as well as to the medical profession.

WENDELL MUNCIE

MODERN ATTITUDES IN PSYCHIATRY. *The March of Medicine, 1945. Number X of the New York Academy of Medicine Lectures to the Laity.*

By Iago Galdston and others. Columbia University Press, New York. $2.00. xiv + 154 pp. 1946.

The 1945 series comprises the following lectures: Iago Galdston, "Psychiatry in the History of Medicine"; James H. Wall, "The Development of Modern Psychiatry"; G. Canby Robinson, "The Patient as a Person: The Social Aspects of Illness"; Franz Alexander, "Present Trends in Psychiatry and the Future Outlook"; Col. William C. Menninger, "Psychiatry and the War"; Edward Weiss, "Psychotherapy in Everyday Practice." These are well developed topics at the hands of experts and are couched in language which the laity can understand. Of especially timely interest is the lecture by Weiss, which is presented from the standpoint of an internist with psychiatric understanding.

WENDELL MUNCIE

THE PSYCHOANALYTIC THEORY OF NEUROSIS.

By Otto Fenichel. W. W. Norton & Company, New York. $7.50. x + 703 pp. 1945.

Fenichel taught for nearly twenty years at various psychoanalytic institutes in Europe and America. In 1932 he published a text, *Spezielle Psychoanalytische Neurosenlehre*, which was translated by Lewin and Zilboorg and published in 1934 under the title *Outline of Clinical Psychoanalysis*. This was greeted as the first serious attempt to write a systematic text on the subject of psychoanalytic psychopathology as found under various diagnostic labels, that is, the first book comparable to the texts on pathology which are familiar in physical medicine. The present book is in a way a new and, in this reviewer's eyes, a greatly superior edition of that book and is still quite the best expression, in one volume, of psychoanalytic theory.

This book is more than that, for it includes a section on general psychoanalytic theory apart from theory of special diseases. In this section there is an introduction of thirty-two pages in which, for the uninitiated, remarks about certain general assumptions in psychoanalysis are included. Here are discussed the dynamic, economic, and structural points of view, and also something of the psychoanalytic method of research. There then follows a section called The Mental Development. Here, in seventy-four pages, is a concise and adequate report of psychoanalytic experience and ideas concerning the development of the psyche in the child. The material is greatly condensed from a considerable literature, but it is inclusive, coherent, and sequential.

The next section of the book is a second edition of the author's first book on the subject. It is a reliable report of the best thinking of psychoanalysts, including Freud and his more distinguished followers, on the various subjects discussed. These subjects are: A) Traumatic Neuroses; B) Psychoneuroses; C) Psychoneuroses, Mechanisms of Symptom Formation and Special Neuroses. Parenthetically it may be remarked that Fenichel here uses the word psychoneuroses to include not only the conventional anxiety, conversion

hysteria and obsessional neuroses, but also organ neuroses, pregenital conversions, perversions, depression and mania, and schizophrenia. This is not an eccentricity of the author but the result of the development of psychoanalytic thought and experiences to the belief that all these disorders belong in some degree together. D) Psychoneuroses, The Second Elaboration of Symptoms. In this section are discussed the defenses against symptoms, the secondary gains from symptoms, and, in a separate chapter, the Character Neuroses. E) This section discusses the combination of Traumatic Neuroses and Psychoneuroses. F) The last section discusses the course and therapy of the neuroses. This book is not a text on therapy; therefore this section gives only to a general outline.

The bibliography, which impresses this reviewer as exceptionally adequate for any student of psychoanalysis, is, however, introduced with an apology to the effect that due to the war-time paper shortage it is not complete and includes references only to books and papers referred to in the text, and it is further stated that the literature has been considered only through 1943. The bibliography is presented alphabetically in terms of authors but is keyed to the text, so that a reader of this book can find ready reference to the original sources of the material he reads.

This book is a condensation of the literature of psychoanalysis and is written as a text for psychiatrists who are studying psychoanalysis. As such it is exceptionally sound, a fair and impartial report of the literature up to now. The author has at no time presented a one-sided attack or defense. He makes numerous references to non-psychoanalytic writers. If one wants to know what psychoanalysts teach their students, here is the text. While the language is that commonly used in analysis, words are so defined that any intelligent layman who is interested will appreciate the substance of the discussions.

In conclusion, this reviewer must express the grief of psychoanalysts everywhere over the untimely death of the author.

LEWIS B. HILL

(PSYCHO-) ANALYZE YOURSELF—*Enabling Anyone to Become Deeply Psycho-Analyzed without a Personal Analyst.*

By E. Pickworth Farrow; foreword by the late Sigmund Freud. International Universities Press, New York. $2.00. xv + 157 pp. 1945.

This little book contains the following foreword by Sigmund Freud:

"The author of this book is known to me as a man of strong and independent intelligence who, probably on account of a certain wilfulness of character, could not get on well with the two analysts with whom he experimented. He then had recourse to a consistent application of the process of self-analysis which I had once used myself in order to analyze my own dreams. His results deserve notice, especially because of his special individuality and his technique."

Getting off to this non-committal start at the hands of the master does not detract in the least from the interest the reader will have in this little volume. The author pursued analysis with two analysts and finally resorted to self-analysis, sticking to free-association as the essential factor and arriving at some extremely interesting memories, if such they may be called, going back to six months of age. The recovery of these memories served to bring the author notable alleviation in a number of neurotic symptoms. In passing, it may be noted that a tremendous amount of time was spent in the process.

The author comes to some final observations, deviating strongly from current analytic teaching, the most important being the following:

1) The process of free association and the recovery of ancient memories, rather than the transference situation, constitute the vital process in analysis.
2) The repressed sexual factors, which are probably universal, are important, but secondary to the observations of the self-preservation instinct, which he considers the final cause in the development of neurosis.
3) The slaps and blows administered in early infancy have a profound effect on the development of inferiority feelings and other neurotic traits.

This little book is full of interesting observations, speculations, and theories, and if for no other reason, would be interesting in the portrayal of the feelings and thoughts of a man who tried traditional analysis with two analysts, was critical of them for understandable reasons, and turned to self-analysis as a method of choice.

WENDELL MUNCIE

EVERYDAY PSYCHIATRY.

By John D. Campbell. J. B. Lippincott Company, Lippincott Company, Philadelphia, London, and Montreal. $6.00. xiv + 333 pp. 1945.

This volume, written by a general practitioner who turned to neurology and psychiatry and who is now in the military service, is essentially a discussion of various types of psychopathic personalities and of psychoneurosis. It is an eclectic presentation of modern psychiatric thought, with gleanings from the psychoanalytic and constitutional fields particularly, and documented with case material from his military experience. The book is highly readable and a rather personal document, and undoubtedly of value to the group for which it is intended.

WENDELL MUNCIE

MODERN TRENDS IN CHILD PSYCHIATRY.

Edited by Nolan D. C. Lewis and Bernard L. Pacella. International Universities Press, New York. $6.00. 341 pp. 1945.

This book contains another collection of papers loosely grouped together under a sufficiently general title to allow a very diffuse survey of its field. Contributors to this anthology represent some of the best known names in child psychiatry, and a glance at the table of contents is extremely impressive. Under such circumstances, an interested reader cannot fail to begin this volume with utmost anticipation, a state of mind which is quickly replaced by disappointment as he goes farther.

There are seventeen articles in this volume which the editors feel cover the areas of diagnosis, etiology, and therapy. Since these subdivisions are not clearly defined in the body of the book, the task of reviewing becomes even more staggering. Perhaps the most practical method of dealing with the problem involved is to comment on a few of the papers, selected at random, in the hope that such a sampling will reveal the general level of performance in the book as a whole.

Margaret S. Mahler has an article entitled "Ego Psychology Applied to Behavior Problems." It is short but concisely written and is about the most thought-provoking of any of the articles. She makes the point, not entirely unique, that "the mental health of the child is commensurable with his ego strength" and that the ego development is traumatized when there is a disruption of the patient's object-relationships, particularly severe if this occurs early in life and on a very primitive level. This paper follows in sequence a paper by J. H. W. Ophuijsen on "Primary Conduct Disturbances," in which he, too, emphasizes the factor of poor object-relationship and the failure of the patient to give up narcissistic interests as important in the development of behavior difficulties in children.

The paper by Caroline B. Zachary is called enticingly "A New Tool in Psychotherapy with Adolescents." The "new tool," it turns out, is the High School. The author spends ten discursive pages on the advisability of "a superior modern school" staffed by "warm, understanding persons who respond sensitively to their students."

Lewis J. Doshay, psychiatrist at the Children's Court in New York City, takes as his topic "Male Sex Delinquency and Community Responsibilities." This article is impressive less for its content than for its unusually emphatic style. So many of what the author must feel are "significant phrases" are italicized that the reader can only feel irritated and exhausted by the time he completes the paper, if he does. Wading through the italics, however, one finds that Doshay has presented primarily a statistical survey of the problem of the male sex delinquent. There is no consideration of the psychodynamics involved in these patients, and the therapy suggested is a matter of improved environment. The author concludes that "the special attention of a *vigorous program is desperately needed*" for the improvement of sex delinquents, for these individuals "help to swell the ranks of the *ever-expanding army of criminals, gangsters, and racketeers.*"

Lauretta Bender presents a paper of thirty-five pages on "Organic Brain Conditions Producing Behavior Disturbances." It is a very thorough, scholarly treatise, painstakingly considering encephalitis, burn encephalopathy, and the traumatic states as etiologic factors in behavior disorders. She makes the point at the end that children with organic brain disorders deserve a complete work-up including a physical, personal, and environmental evaluation. A custom-built rehabilitation program then would increase the patient's chances for a well-adjusted future. While one cannot quarrel with the conclusion, or with the author's systematic approach to her topic, the reader must wonder if the problem of organic brain disorders is so overwhelming in modern child psychiatry that the longest paper of a supposed survey of the whole field is on that subject.

"Play Analysis in Research and Therapy," by J. Louise Despert, is another long paper. She conscientiously and in very business-like fashion gives an overall picture of play analysis. It would be a very illuminating article for someone who has always wondered what psychiatrists get out of just letting children play.

And so the book goes on. The papers of those people who have certainly proved their worth as original thinkers in psychiatry and related fields, such as David M. Levy, Bruno Klopfer, Frederick H. Allen, and Hilda Bruch, are on the whole relatively perfunctory restatements of their previous contributions to the literature. The articles by the other less well-known authors are too frequently on a plane of verbose generalization. To one actively working in the field of child psychiatry, needing stimulating new thought rather than a rehash of familiar and accepted ideas, this book would hardly be worth an investment in time and money.

HELEN H. ARTHUR

THE PSYCHOANALYTIC STUDY OF THE CHILD. *Volume I. Edited by Otto Fenichel, Phyllis Greenacre, Heinz Hartmann, Edith B. Jackson, Ernst Kris, Lawrence S. Kubie, Bertram D. Lewin, Marian C. Putnam, Rene A. Spitz, Anna Freud, Willie Hoffer, and Edward Glover. International Universities Press, New York.* $6.00. 423 pp. 1945.

The Psychoanalytic Study of the Child, edited by Anna Freud, Heinz Hartmann, and Ernst Kris in collaboration with an imposing editorial board of nine other psychoanalysts in Great Britain and the United States,

is Volume I of a proposed series of annuals. This first volume is a rather heterogeneous collection of individual papers loosely grouped together under six main headings and representing, presumably, the most important current contributions to the general field of child analysis.

The book covers an immense area of psychoanalytically oriented thought, presenting material on genetic problems, clinical analyses, guidance work, educational problems, group life, and a section of book reviews. This wide range might prove disconcerting to a reader not already well versed in psychoanalytic lore, who cannot fill in the gaps as the papers leap from theoretical crag to crag. However, taken individually, many of the papers are exceedingly interesting and have ideas of value to anyone doing psychotherapy with children.

The problem of reviewing such a varied assortment of individual articles lumped together as a book is indeed complex, for each paper presents material for comment, question, or criticism. As it is impossible to review each article separately, in this review one paper from each of the five general sections will be considered, with a special effort to select the papers that might be of interest also to those readers not particularly trained psychoanalytically.

In Section I, Genetic Problems, Rene A. Spitz has an article on "Hospitalism, an Inquiry into the Genesis of Psychiatric Conditions in Early Childhood." This study is "especially concerned with the effect of continuous institutional care of infants under one year of age for reasons other than sickness." Spitz elected to investigate the development of children under one year of age reared in 1) the nursery of a penal institution for delinquent girls, 2) a foundling home, and 3) private homes in the surrounding community. He has done a very thorough piece of research and is able to point convincingly to the significance of the mother-child relationship as a genetic factor in the emotional development of this age group. This is not an entirely original conclusion, but it does emphasize the factors that need to be considered and improved upon for the institutionalized youngster.

Other papers in this section deal with the birth trauma as a genetic factor in emotional development, clinical notes on the discovery of a primal scene via analysis, the need for a more genetic approach in psychoanalysis, and a masterly rebuttal of the Klein System of Child Psychology.

Section II has to do with the clinical concepts of child analysis. Anna Freud presents a lucid survey of the field of child analysis. She makes the reassuring and intelligent point that "child analysis should be used in cases where there is slight or no hope of a spontaneous recovery," not as a general treatment for every behavior problem. After setting her stage very neatly, Miss Freud continues by elaborating on what emotional developmental anomalies are indicative of serious disorders and how the analyst or psychiatrist must be thoroughly familiar with the normal developmental process in order to assess the abnormal. It is a most stimulating paper.

Other contributors to this section are Berta Bornstein, Emmy Sylvester, Kate Friedlander, and Dorothy Gurlingham. The papers are very interesting from a clinical point of view and most convincing. They convey the impression that modern child analysis is built not only on certain basic theories but also on a common sense approach to, and a warm understanding of, the individual patients.

In the third section, dealing with Guidance Work, Hyman Lippman has an article on "The Use of Dreams in Psychiatric Work with Children," stressing the usefulness of dream material in understanding the fantasy life of the patient. He does not, however, advocate ad lib interpretations. A second paper in this section deserves comment—Emmanuel Klein's study on "The Reluctance to Go to School," in which he assesses the etiological factors in the development of a dread of going to school. He urges that such patients be kept in contact with the school setting, no matter to how slight an extent, in order to prevent the development of a chronic truancy reaction which is so much more complex than the early or "acute" truancy.

The Problems of Education, Section IV, are dealt with in this book by Otto Fenichel, Willie Hoffer, and Edith Streba. Fenichel's article on "The Means of Education" is a discussion on how scientific "study of the psychic characteristics of human beings" can contribute to the improvement of our modern pedagogic influences. It is an interesting paper written more as a philosophical statement than in the spirit of specific reform. Certainly there is a tremendous need for some such consideration in these days when the application of scientific advances in other fields is so dazzling.

Of the papers presented in Section V on The Problems of Group Life, Fritz Redl's study of "The Psychology of Gang Formation and the Treatment of Juvenile Delinquents" is most impressive. Redl writes in an exceedingly clear, compact style about a subject of importance to every educator, group worker, or child therapist. He correlates the factor of group dynamics with the factor of individual dynamics in the juvenile delinquent and states conclusively that a worker must assess one as thoroughly as the other. He makes quite a point of the fact that the juvenile delinquent cannot be treated in "group psychological midair" but must have a frame of reference for changing his group identifications. It is an original thesis, beautifully worked out, and well deserving of study by all who deal with delinquent children.

The last section of Surveys and Comments is devoted to four long reviews on books of current psychoanalytic interest and one survey of the literature on the subject of "Evacuation of Children in Wartime."

Altogether, Volume I of this proposed annual publication is stimulating and refreshing. Some of the papers are, understandably, somewhat esoteric; but the majority make a contribution not only to the field of psychoanalysis but also to the greater field of child psychiatry in general.

HELEN HEWITT ARTHUR

PSYCHE UND HORMON. *Grundfragen der Psychotherapie.*

By Heinrich Meng. Hans Huber, Bern. Schw. Fr. 12.80. 179 pp.; 1 plate. 1944.

This work is an interesting contribution to the development, interpretation, and therapy of organ-neurotic disturbances, although its subtitle, Fundamental Problems of Psychotherapy, remains but a promise. The author does not seem to be much known among the psychosomatic specialists in this country; yet he has devoted considerable thinking to this intricate field within the past twelve years, and longer.

The special value of the publication lies in the endeavor to find in Eugen Steinach's experiments and theory about the sex-hormones a biological foundation for Freud's psychology. There are separate chapters on the life work of each of them, and the reader will appreciate that on Steinach.

Another chapter deals with the etiology and psychotherapy of what Meng calls "organ-psychosis." This ambiguous and superfluous term was introduced by Meng in 1934 (*Intern. Z. Psychoanal. 20*, 439–458). He differentiates organ-psychosis from organ-neurosis. In a neurosis the ego is only secondarily involved by reactions and compromises. The conflicts manifest themselves in functional disturbances, i.e., quantitative symptoms of inhibition and exhaustion of organs. In an organ-psychosis, however, the ego is primarily affected and overwhelmed by the victorous It; somatic functions are secondarily and qualitatively disturbed by the psychosis. Such psychosis may develop if a neurotic compromise was not achieved or did not suffice. Meng stresses the importance of immunization through early neurosis. The concept of organ-psychosis is illustrated by some of the authors' cases of "cachexia," which yielded to psychotherapy after medical treatment had failed. In a last chapter the—omitted—footnotes are given as commentary, and provide some interesting reading.

WALTER O. JAHRREISS

MEN, MIND, AND POWER.

By David Abrahamsen. Columbia University Press, New York. $2.00. ix + 155 pp. 1945.

In this book the author, a Norwegian psychiatrist who is now working in this country, attempts to examine the psychology of the German people as viewed historically, to determine why the Germans became Nazis, and to paint psychological portraits of leading spirits in the Nazi movement, Hitler, Goebbels, Himmler, Goering, and of the two traitors, Quisling and Laval.

As a psychiatrist, I am not deeply impressed by his analysis of the German mentality nor convinced by the psychological explanations of why the Germans became Nazis. It all sounds too simple, too full of assumption, and even of bias. For example, when he describes the German language as harsh and draws some relationship between this and the German character, it is hard to follow. He also finds something very sinister in the "Pied Piper of Hamlin," and says that the story is so explicitly German that no one else can comprehend it. I wonder about this! The portraits of the master minds of the Nazi movement and of the Quislings also suffer from over-simplification. This book is not a serious contribution to the very real problems raised by the Nazi movement.

WENDELL MUNCIE

RE-EDUCATION IN A NURSERY GROUP: A STUDY IN CLINICAL PSYCHOLOGY. *Monographs of the Society for Research in Child Development, Volume IX, Number 2. (Serial No. 38).*

By Ruth Wendell Washburn. Society for Research in Child Development, National Research Council, Washington. $2.00 (paper). 175 pp. 1944.

SOCIAL AND EMOTIONAL ADJUSTMENTS OF REGULARLY PROMOTED AND NON-PROMOTED PUPILS. *Child Development Monographs No. 32.*

By Adolph A. Sandin. Bureau of Publications, Teachers College, Columbia University, New York. $2.15 (paper). ix + 142 pp. 1944.

HUMAN BIOLOGY

A COMPARATIVE STUDY OF HUMAN REPRODUCTION. *Yale University Publications in Anthropology Number 32.*

By Clellan Stearns Ford. Yale University Press, New Haven; Humphrey Milford, Oxford University Press, London. $1.50 (paper). 111 pp. 1945.

The author has analysed the customs surrounding the biological facts of reproduction (menstruation, cohabitation, conception, pregnancy, childbirth, lactation) in 64 tribes. He set out to prove that the "cultural rules for behavior which characterize any society are neither accidental nor meaningless. Nor again are these rules instinctive or innate. Rather they are rules learned through the experiences of success. Other kinds of responses have been tried and have failed to be rewarded; these do not persist." It might have been useful if the author had been aware of at least two

fundamental biological facts: that 98 per cent of all human deliveries are normal; and that more than 50 per cent of all infants die in primitive societies anyhow. Therefore "success" and "failure" are hardly a proper frame of reference in these cases, especially when taken very literally. The author's ardent attempts to invest with biological meaning almost all the numerous "successful" taboos in menstruation, pregnancy, etc., whether they are physiologically useful, irrelevant, or obnoxious, are more touching than convincing. His discovery that the customs surrounding reproduction are not entirely arbitrary is perhaps less surprising, in view of the fact that such customs have to observe everywhere the same biological limits. The author has collected a great number of interesting data, though his sample is too small to show the whole range of customs in human societies.

ERWIN H. ACKERKNECHT

PEGUCHE, *Canton of Otavalo, Province of Imbabura, Ecuador. A Study of Andean Indians. The University of Chicago Publications in Anthropology. Ethnological Series.*

By Elsie Clews Parsons. University of Chicago Press, Chicago. $3.00. viii + 225 pp.; 40 plates. 1945.

In this last book the late E. C. Parsons gives the results of two summers of field work in an Indian village in northern Ecuador. The life of these peasants, former subjects of the Inca Emperor and the King of Spain, is rather different from the life of the customary objects of anthropological research. It is much closer to peasant life in medieval western or present day eastern Europe and Asia, a fact which makes this study all the more interesting. Though Ecuador was only 70 years under Inca rule, the population studied by the author speaks Quechua and shows such an amount of classic Inca traits that actual population exchange by the Incas seems likely. Parallels with the wild tribes of eastern Ecuador are rare, and the Spanish veneer is but thin. The technology, daily life, and religion of these peasants are described with a clarity, richness, and human penetration, such as only the regretted author had at her disposal. The study fits in well with others on Spanish-Indian acculturation, a field that was inaugurated by the author and is cultivated now by Redfield, Tax, Beals, Gillin, and others.

ERWIN H. ACKERKNECHT

THE MAYA OF EAST CENTRAL QUINTANA ROO. *Publication 559.*

By Alfonso Villa R. Carnegie Institution of Washington, Washington. $2.75 (cloth); $2.25 (paper). xii + 182 pp.; 6 plates. 1945.

The Maya of East Central Quintana Roo are a group that after strong Spanish influences threw off Spanish control and have led an isolated existence for a long period. This monographic study of their life is characteristic of one of the modern anthropologic trends in attempting to portray as completely as possible the material culture, economic life, social and political organization, religious life, medical treatment, and cosmology. A full and rounded picture of the people is aimed at. This is a first-hand report by a student who has taken a great deal of time and obtained a wealth of detail. This detail is presented factually, with a minimum of theoretical consideration. The study will be a most useful source of information for students of these or related peoples, or for those seeking examples of primitive medicine, beliefs, etc. The weird blending of Catholic and Mayan ritual and beliefs is of particular interest.

GEORGE F. CARTER

WARRIORS WITHOUT WEAPONS. *A Study of the Society and Personality Development of the Pine Ridge Sioux.*

By Gordon Macgregor, with the collaboration of Royal B. Hassrick and William E. Henry. University of Chicago Press, Chicago. $3.75. 228 pp. 1946.

This volume is one of the five integrative studies of Indian personality sponsored by the Office of Indian Affairs and the Committee on Human Development of the University of Chicago. It deals with the Pine Ridge Sioux of South Dakota. Driven into reservations in 1869, the Sioux had reached a satisfactory adjustment as cattlebreeders in the first decades of this century. The "voluntary" sale of their lands and cattle around 1920 seems to have been an even worse shock to them, economically and morally, than segregation and the disappearance of the buffalo.

Situated between two cultures and belonging to none, the present day Sioux live in a permanent state of psychological and economic insecurity and dependence. They have developed a mentality which seems characterized primarily by apathy, escapism into daydreams of past glory, or into actual running away and other explosive reactions. Anthropological analysis of the surviving old culture elements, like excessive hospitality, explains ingeniously "odd" traits like the preference of the present-day Sioux for wage-earning instead of cattle breeding. The mentality of the living grandparental and parental generations is ably analysed in reference to the structure of reservation society during their respective youths. The emphasis of the study is, as in the four companion studies on the Navaho, Hopi, Zuñi, and Papago, on child psychology, explored with a battery of tests (Grace Arthur point, Goodenough draw-a-man, Murray's thematic appreciation, Rorschach, etc.) in 200 children ranging from 6 to 18,

and from full blood to less than one fourth Indian blood. The average IQ does not differ from the average found in white Midwestern children. Forty per cent of the children examined were found to be undernourished. The tests show that the world appears hostile to these children; withdrawal from the outer world becomes very marked in adolescence; the most pleasant experiences are still connected with the badly shattered and disintegrated family.

A great amount of information and intelligent analysis has been crowded into this excellent little book, which will be welcomed by anthropologists, sociologists, and psychologists alike.

ERWIN H. ACKERKNECHT

CHANGING CONFIGURATIONS IN THE SOCIAL ORGANIZATION OF A BLACKFOOT TRIBE DURING THE RESERVE PERIOD (*The Blood of Alberta, Canada*). OBSERVATIONS ON NORTHERN BLACKFOOT KINSHIP. *Monographs of the American Ethnological Society, VIII and IX.*

VIII: By Esther S. Goldfrank; IX: By L. M. Hanks, Jr., and Jane Richardson. J. J. Augustin, New York. VIII: vii + 73 pp.; 4 plates. IX: v + 31 pp. 1945.

During the last 60 years the Blood subgroup of the Blackfoot, the subject of Mrs. Goldfrank's interesting study, has changed from buffalo hunting, through mere living on government rations and cattle breeding, to wheat farming. Though these changes have thoroughly shaken the social and mental set-up of the group, some fundamental traits, such as individualism and competitiveness, have been rather reinforced. The author has collected a wealth of excellent material and presents it very ably in a well organized form. L. M. Hanks, Jr. and Jane Richardson contribute competent observations on the kinship system of the Northern Blackfoot.

ERWIN H. ACKERKNECHT

NATIVE PEOPLES OF THE PACIFIC WORLD. *The Pacific World Series.*

By Felix M. Keesing. The Macmillan Company, New York. $3.00. xv + 144 pp.; 32 plates. 1945.

This little handbook, which was also issued by the Infantry Journal, is a most fortunate solution of what at first sight seems an impossible task: in less than 150 pages to prepare the travelling Westerner, soldier or civilian, for a sympathetic contact with the hundreds of different native peoples and cultures that he is bound to meet between Singapore and Easter Island. After providing a minimum of positive information on the great cultural, racial, and linguistic divisions of the populations of the Pacific (the Indonesians, Philippinos, Micronesians, Melanesians, and Polynesians), the author outlines what a visitor might encounter in the way of different forms of government, economics, industries, religions, family structure, and customs; and sketches the problems arising from acculturation of the natives. The result of this method of presentation is excellent. Though a great number of facts are stated, this is, of course, no "reference" book (there is unfortunately no reference book on the Pacific comparable to books existing on Africa or America). Yet Keesing accomplishes what no cramming of facts could do: he conveys to the reader the right approach to the primitives of the Pacific. This is applied anthropology, a field about which I often feel individually rather sceptical, at its best. An outstanding scholar has here done a job in popularizing which is incomparably superior to the regrettable products we usually meet under such a label.

ERWIN H. ACKERKNECHT

BIBLIOGRAPHY OF INDONESIAN PEOPLES AND CULTURES. *Yale Anthropological Studies, Volume 4.*

By Raymond Kennedy. Yale University Press, New Haven; Humphrey Milford, Oxford University Press, London. $2.50 (paper). 212 pp. 1945.

This bibliography deals mainly with the anthropology and sociology (including ethnography, archeology, linguistics, and acculturation studies) of Indonesia. But many borderline studies, e.g., on geography, administration, and economics, are included, and standard references on the natural sciences (zoology, botany, and geology) are also listed. The eight main divisions of the bibliography are: Indonesia (general), Sumatra, Java, Borneo, Celebes, the lesser Sundas, the Moluccas, and Netherlands New Guinea. A time-saving device is the separation of Dutch titles from those in other European languages. Prepared at Yale, which possesses the most complete Indonesian ethnographic library in the world, outside the Netherlands and the Indies themselves, and by the foremost authority on the region among American anthropologists, this is a most welcome and most excellent tool for all those—and their number is not small and will increase steadily—who for one reason or another are interested in Indonesia.

ERWIN H. ACKERKNECHT

SOUTHERN CALIFORNIA COUNTRY: *An Island on the Land. American Folkways.*

By Carey McWilliams. Duell, Sloan & Pearce, New York. $3.75. xii + 387 pp. 1946.

Of the making of many books about southern California there seems to be no end, and the reading of them is a weariness of the flesh. The work here under discussion is peculiar in that it comes from the pen of a resident

of the state—the state generally depends upon transient visitors for publicity.

Southern California, as the author conceives it, is that part of the state lying south of the Tehachapi—the mountain range that bisects California into two parts each of which rotates about its own metropolis and steadfastly ignores the other. But the difference between the two is only political. It is doubtful if the average visitor from that mysterious realm known vaguely to Californians as "the East" is ever conscious of any change as he crosses the great divide. On each side are to be found the same boosters, boasters, and bigots, and the same mutual distrust. Even the countryside looks the same.

Yet there is one geographical discontinuity which has so impressed itself on the personalities of the two populations dwelling on each side that no visitor can cross it without realizing that he is entering a new country. This boundary coincides approximately with the San Gorgonio Pass and the Santa Ana River. North of this latitude the Coast Range stands in close proximity to the ocean; an altitude of 6000 feet occurs within a few miles of the city limits of Pasadena and Santa Barbara. On the other hand, residents of San Diego have to travel inland fifty miles or more to reach a comparable altitude in the Sierras. The moisture-laden clouds from the Pacific are forced to surrender their life-giving cargo within a narrow strip north of this boundary; south of it the precipitation is distributed over the foothills in an extended range of longitude. The result is that San Diego, with three rainy seasons each year as against two for Los Angeles and one for San Francisco, gets less than half the rainfall of the more northerly cities.

This difference has profoundly affected the way of life of the residents of Southern California. The Angelenos, with their superior water supply, found that they could live as they had been accustomed to at home, and went in heavily for the extensive lawns and cultivated gardens which characterize the better residence districts of Pasadena even today. Quickly they brought to fruition the Biblical prophecy about the desert blossoming as the rose. The San Diegans took for their motto another text from the same writer—every valley shall be filled, and every mountain and hill made low. The most characteristic feature of every San Diego landscape is the steam shovel, and probably nowhere else has the face of nature been subjected to such a strenuous course of face lifting. A generation ago it was the boast of San Diego that its harbor, which William H. Emory considered superior to that of San Francisco, could shelter all the navies of the world simultaneously; today it hardly suffices for our own. A few more years is likely to see it completely filled and serving as a landing field. It is interesting to note that while this filling has been going on, the city of Los Angeles was dredging an ill-smelling slough of mud and converting it into the most active commercial seaport in the western hemisphere.

It is easier to criticise a book like this than to write one. The author has done a highly creditable piece of work in telling the truth about the zoot suit riots, the fight for free speech conducted by the I. W. W., and the pogroms indulged in by the reprehensible Captain William Hynes. It is too bad that he did not recount the persecution of Floyd Hardin and Harold Story as well. But to those who, like the present reviewer, have been a resident of the state nearly twice as long as the author, the careless errors which a little diligent proofreading might have eliminated are a continuous source of irritation and annoyance. For instance, the distinction between high and low fog is credited to S. P. Ford, when Ford A. Carpenter was obviously meant. McWilliams states that the Mission Inn at Riverside was designed by Myron Hunt—a *lapsus calami* for Arthur Benton. In one paragraph he states that New Thought did not reach Los Angeles until after the San Diego Exposition in 1915, and in the next that it was flourishing in the same city in 1904. (The latter statement is closer to the truth.) He makes the conflicting statements that Aimee Semple McPherson never contended that she could heal the sick, but that she was widely known as a faith healer.

The circumstances surrounding Sister McPherson's rise to influence in California were as follows: She had been holding revival meetings in an abandoned public market for about two years when the two most prominent faith healers of the day, William Hickson and D. W. Wilt, arrived in San Diego for a brief campaign. They were in no sense cult founders. Hickson was an orthodox Anglican and Wilt an orthodox Methodist. They were both emphatic in disclaiming any credit for the cures that occurred during their ministrations, declaring that these were miracles wrought by grace, and neither one received or expected any pecuniary compensation for his services. A short time after their departure Aimee began holding healing services of her own, and her congregation at once assumed such proportions that she was forced to move from the public market to the open air of Balboa Park. From all over the city her clients began to arrive, some on crutches, some in wheel chairs, the lame, the halt, and the blind. The street railway was taxed over its capacity by the crowds that began to assemble three hours before the time set for the services. In a few months Aimee began to look for fresh fields and pastures new, which makes the present reviewer inclined to suspect that the author had his tongue in his cheek when he appraised her entire fortune on arriving in Los Angeles at $100 and a jalopy.

The author's statement that 900 Mission Indians died every month during the Franciscan ascendency is also somewhat of a strain on the reviewer's credulity. This would be approximately 10,000 deaths a year; a population to maintain itself for sixty years in the face

of such a death rate would require 10,000 births annually or 10,000 women of child-bearing age. On the assumption that one-third of the female population would be too young and another third too old to bear children, and that the sexes would be numerically equal, the minimum population needed would be around 60,000, of which every woman would be fertile and would live until after she had ceased to bear children. Such conditions are never achieved in nature. A population estimate of 100,000 would seem more reasonable. Estimates of Indian population in past centuries are hard to come by; the only one the reviewer can recall is that given by Sharpless in *Two Centuries of Pennsylvania History*, in which he estimates that the Indian population of America north of Mexico probably never exceeded 300,000 in the colonial period. If these figures are correct, one must believe that one out of every three Indians in the United States and Canada lived in the Franciscan Missions of California. It seems more likely that the author was merely indulging in some of the California hyperbole for which he castigates George Wharton James.

One puts down this book with the feeling that the author has attempted to cover too much ground. There is no phase of California history which he fails to touch upon (except the explorations of the scientists such as Thomas Nuttall, Titian Peale, R. E. C. Stearns, Cyrus Pringle, T. S. Brandegee, or in our own time, Kate O. Sessions), but he jumps so quickly from one to another that he leaves untold much that is fundamental to the story. For instance, in enumerating the cultural lights who have made their homes in the state he very justly mentions Madame Modjeska, Sienkiewicz, Beatrice Harraden, Charles F. Lummis, and Charles F. Holder, to mention but a few selected at random. But he says nothing of Madame Schumann-Heink, or Max Heinrich and his wife Anna Held, whose Green Dragon colony in La Jolla was the mecca of all visiting intelligentsia for over a quarter century. He points out that Paderewski was a property owner in northern California, but overlooks Teresa Carreño, Enrico Caruso, and Owen Wister, who owned real estate in San Diego.

One really important, influential, and significant figure in California history has been rescued from an undeserved oblivion in this book—Irving Gill, the architect. The reviewer knew Gill personally and believes the praise bestowed upon him by the author to be well merited, but he doubts whether Gill would have considered it a compliment to be classified with Frank Lloyd Wright.

The author has made it clear that he is not writing a work of history. The reader who struggles through the chapters dealing with the Franciscan period will have no difficulty in understanding this. The rest of the book shows a decided preference for the erratic and picturesque denizens of the state than for the solid citizens who really developed it but who would not have made such interesting reading. However, in attempting to tell about these he has only scratched the surface. A few statements about Jackson Barnett, or about the Clark family, would have spiced the book up considerably.

The author has provided an index, but it is very inadequate. The best way to locate any specific passage which the reader remembers is to read the book again, and that is not an ungrateful task.

THE PECKHAM EXPERIMENT: *A Study in the Living Structure of Society. A Sir Halley Stewart Trust Publication.*

By Innes H. Pearse and Lucy H. Crocker. Yale University Press, New Haven. $3.50. 333 pp. 1945.

Peckham Health Center, situated in a suburb of London, had unfortunately to close because of the war. It was an absolutely unique experiment in promoting and studying health and social integration by means of a giant neighborhood club, based on periodic health overhauls and common spending of the leisure hours of more than 1000 families.

This book gives the theoretical foundations which prompted the Peckham Center's initiators, as well as the story of their experiences. Akin to the Montessori method in education, the accent was very sensibly put on self-reliance and self-development. The family was adopted quite seriously and rather convincingly as the fundamental biological unit, and "health," and not the prevention or treatment of disease, was the goal. "Health" in the authors' definition was found in only 9 per cent of their material. 32 per cent suffered from disease; 59 per cent, though apparently well, from compensated disorders. The old term "Health," as used by the authors, is a new notion and ideal. It is obvious that in any earlier population, percentages of this kind of health would have been infinitesimal. But the notion is consistent with the general orientation of most of our contemporaries who unconsciously have replaced God and other values by health. Logically one of the most significant sociological experiments of our time is carried out in this way by biologists, who are just as unaware of the cultural conditioning of their values as sociologists in general, familiar at best with a little psychopathology, are unaware of biological implications.

Many statements of the book appear to be based more on theory than on actual observations. Its style, somewhat flowery, repetitious, and missionary, is certainly neither the scientifically traditional nor to everybody's liking. It seems to me that this type of Health Center can never become a general feature, or at least only in a society not very desirable from other points of view. The ideals of the book do not happen to be mine. Yet I sympathize with an experiment where at least something was done to counter the catastrophic

atrophy of man in our society. The book is so crammed with valuable observations and ideas, so full of life and vigor, so stimulating in its new approach, so sincere and honest in its enthusiasm that I count it among the most interesting I have read in many years, and feel that biologists, doctors, sociologists, anthropologists, and laymen alike would greatly profit from studying it.

ERWIN H. ACKERKNECHT

ALCOHOL, SCIENCE AND SOCIETY. *Twenty-nine Lectures with Discussions as Given at the Yale Summer School of Alcohol Studies.*

Quarterly Journal of Studies on Alcohol, New Haven. $5.00. xii + 473 pp. 1945.

This volume consists of twenty-nine lectures and discussions transcribed from sessions held at a school for the study of the problem during 1944. While the project is described as "an experiment in social education," and the intention as "an attempt toward the definition of the problems of alcohol and alcoholism in scientific terms," this reviewer does not believe that the goals have been adequately realized. Very little of immediately applicable *practical* information results from a careful reading of the book, and the medical-psychological point of view is obscured beneath a mass of material which diverts attention from the main issues of the problem. On the whole, psychiatric workers in the field of alcoholism and medical psychologists who have to cope with alcoholics in practice will be disappointed.

ROBERT V. SELIGER

BIOMETRY

STATISTICAL METHODS *Applied to Experiments in Agriculture and Biology. Fourth Edition.*

By George W. Snedecor. The Iowa State College Press, The Collegiate Press, Ames. $4.50. xvi + 485 pp. 1946.

The three earlier editions of this standard textbook and reference have been previously reviewed in this section (Q. R. B. 13: 376; 14: 264; 16: 242). The new revision shows a considerable amount of rewriting and rearrangement, and the scope of the treatment has been enlarged to give "greater emphasis . . . on the theoretical conditions in which the various statistical methods have validity, and . . . on the conduct of the experiment so as to incorporate in the data the information desired; estimates and fiducial statements have been brought into equal prominence with tests of hypotheses; there is increased reliance on experimental samplings to exemplify distribution theory; the treatment of correlation and experimental designs has been expanded; and the methods for disproportionate subclass numbers have been extended to include all those necessary for ordinary needs."

The outstanding characteristics of the book remain its clear and easy style, its abundance of excellent, practical examples, its central emphasis on the analysis of variance, and its focus on the relation of statistics to experimental work in a variety of fields. Biologists will find it among the most valuable books on their shelves. Students should be grateful for so stimulating and effective an approach to the subject.

BENTLEY GLASS

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

SCIENCE YEAR BOOK OF 1946.

Edited and with an introduction by J. D. Ratcliff. Doubleday & Company, Garden City, New York $2.50. xxxv + 245 pp. 1946.

Like previous books of this series, this volume contains popular articles on scientific subjects grouped under the general categories of Physics and Chemistry, Medicine, Agriculture, and Aviation and Other Sciences. Together with the editor's Introduction, which effectively fills some of the gaps in the array of chosen topics, these articles present a broad and varied survey of the year's brightest scientific and technological achievements. The writing varies from florid overenthusiasm to balanced and effective presentation.

Ratcliff himself discusses recent developments in synthesizing gasoline from natural gas, in extracting vitamin E from vegetable oil refuse, in curbing thyroid activity with thiourea and thiouracil, and in using amplified mosquito mating calls to trap mosquitoes. As in previous years, he contributes some of the best writing in the volume.

Biologists will read with interest the articles on "Wood: Basis for a New Chemical Industry," and "Chemical Magic: Textiles from Chicken Feathers." The section on Medicine considers streptomycin, amino acid therapy, research on heart disease and cancer, the fertilization of human ova and the initiation of cleavage *in vitro*, use of glycol sprays and preventive sulfa treatment to minimize respiratory illnesses, the Rh factor in blood, the dramatic Lempert fenestration operation to restore hearing in cases of otosclerosis, and advances in psychosomatic medicine. In Part III, on Agriculture, one of the most interesting articles discusses the production of cheap thyroprotein from skim milk and the use of this or of thiouracil to modify, to a remarkable degree, both livestock and poultry for economic uses. Weed and insect killers, plant hormones, and kudzu as a savior of badly eroded land follow to make this an exciting section in its revelation of things to come and of solutions to serious problems. Two concluding articles, one dealing with the effect of military development in opening up Alaska to exten-

sive paleontological study, and the other a reprint of Roy Chapman Andrews' concluding chapter, "Man One Half Million Years Hence," from *Meet Your Ancestors*, combine to make this a richer and more stimulating volume than either of its two immediate precursors in the series.

BENTLEY GLASS

A TREASURY OF SCIENCE. *Enlarged Edition with a complete, new section on atomic fission.*

Edited by Harlow Shapley, Samuel Rapport, and Helen Wright. Harper & Brothers, New York and London. $3.95. xii + 772 pp. 1946.

The first edition, reviewed recently in this journal (Q. R. B. 19: 182), has been enlarged by an extension of the selection from Jeans' *The Universe Around Us* on "Exploring the Atom," and by the inclusion of an entire new section of 82 pages on Atomic Fission, giving the War Dept. Release on the New Mexico Test, extensive portions of Henry D. Smyth's report on "Atomic Energy for Military Purposes," the essay on "Nuclear Physics and Biology" by E. O. Lawrence from *Molecular Films, the Cyclotron, and the New Biology*, an excerpt from *Almighty Atom* by John J. O'Neill, and two new essays, one by Jacob Viner on "The Implications of the Atomic Bomb for International Relations" and the other by J. R. Oppenheimer on "Atomic Weapons." Every scientist will be glad to have these inclusions.

SCIENCE IN A CHANGING WORLD. *Revised Edition.*

By Emmett James Cable, Robert Ward Getchell, and William Henry Kadesch. Prentice-Hall, New York. $5.00. xvii + 622 pp. 1946.

This interesting and well-written treatise of the physical sciences, just revised, is already due to receive further extensive revision, since the present revision seems to have been virtually completed before August 6, 1945. Atomic fission and atomic energy, either for warlike or peaceful purposes, receive scant mention. One will look in vain for the atomic pile, while plutonium and the atomic bomb are briefly mentioned in a single page devoted to atomic fission and a 5-line paragraph elsewhere. This is due to one of those whims of fortune not chargeable to the authors, but it will inevitably detract from the usefulness of their book.

A biologist will look in vain here for any very frequent application of physical and chemical principles and phenomena to living organisms. The chief exception to this is in the treatment of the eye in connection with optical instruments. The elementary accounts of the cyclotron, betatron, electron microscope, and other new tools of science will have some usefulness.

MOLECULAR FILMS, THE CYCLOTRON, AND THE NEW BIOLOGY.

By Hugh Stott Taylor, Ernest O. Lawrence, and Irving Langmuir; introduction by J. R. Dunning. Rutgers University Press, New Brunswick. $2.00. x + 86 pp. + 16 plates. 1946.

This slender volume, first issued in 1942, and reviewed in this section (Q. R. B. 18: 103), contains three excellent papers: Fundamental Science from Phlogiston to Cyclotron, by Hugh Stott Taylor; Molecular Films in Chemistry and Biology, by Irving Langmuir; Nuclear Physics and Biology, by E. O. Lawrence. With a brief added Introduction—Background to Atomic Energy, by J. R. Dunning—it is now reissued as another sign of the times.

THE ELECTRON MICROSCOPE. *An Introduction to Its Fundamental Principles and Applications. Second Edition.*

By E. F. Burton and W. H. Kohl. Reinhold Publishing Corporation, New York. $4.00. 325 pp. + 3 plates. 1946.

Few fields have seen a more rapid development in the past four years than electron microscopy. This is at once clear from the very extensive alterations required in the revision of the first edition of this book, reviewed Q. R. B. 18: 107. The authors have been very diligent in revision, judging from the great number of new papers listed and referred to, from the inclusion of entirely new topics, such as surface replicas and shadow electron micrography, and from added illustrations which further enrich the text. The chapter on the history of the electron microscope has been deleted and its contents partly inserted elsewhere. The treatment of electron optics has been considerably amplified, and the chapters on the compound magnetic electron microscope and the applications of the electron microscope have been wholly or partly rewritten. Some specialized material, such as the description of the Johannsen-Brüche electrostatic electron microscope, has been eliminated. Now, even more than in its first edition, *The Electron Microscope* fits perfectly into a place between such popular books as Hawley's *Seeing the Invisible*, on the one hand, and the more technical treatises, on the other.

There are subject and author indices; and an extensive bibliography, arranged by categories of subject-matter, has been added in the new edition. Unfortunately, the individual titles are arranged in chronological order, and the categories do not correspond to the chapters of the book, so that it is extremely laborious to find the listing of a reference. It is certainly to be hoped that this defect will be remedied in the third edition, which will no doubt, in so rapidly advancing a field, be with us in a year or two.

BENTLEY GLASS

ELECTRON OPTICS AND THE ELECTRON MICROSCOPE. *By V. K. Zworykin, G. A. Morton, E. G. Ramberg, J. Hillier, and A. W. Vance. John Wiley and Sons, New York; Chapman & Hall, London.* $10.00. xii + 766 pp. 1945.

This is a comprehensive treatise, covering all aspects of electron microscopy, theoretical and applied. In dealing with the subject so broadly, it has been necessary to take into consideration the fact that the book will be used by persons with widely different backgrounds. On the one hand, biologists and chemists interested in electron microscopy might be somewhat overwhelmed by the mathematical developments essential to the discussion of the theory and design of electron optical systems. On the other hand, those concerned with theory and problems of design would be ill-served were they not provided with a comparatively rigorous and complete mathematical exposition of the subject.

The authors have solved this dilemma neatly, in my opinion, by their arrangement of the subject matter of the book. The presentation is divided into two parts of approximately equal length, of which the first treats of the practical aspects of the subject and the second treats of theoretical and design aspects.

Part I starts quite simply with an exposition of elementary principles, assuming no background in electronics on the part of the reader. There follow lucid and succinct discussions of simple electron optical systems, electron microscopes and their components, operational and experimental techniques (for example, details of the preparation and handling of specimens), the interpretation of electron photomicrographs, and illustrative applications of electron microscopy to biological, chemical, and metallurgical research. This part should be thoroughly intelligible to readers with but a minimum of training in physics.

Since the emphasis of the book is upon experimental methods, equipment, theory, and design, it could hardly be expected that the section on biological research would be a complete and critical review of the applications of electron microscopy to this field. Biological research is, nevertheless, reviewed with sufficient completeness to orient the uninitiated as to the possibilities and limitations of the technique.

Part II is a systematic development of the theory of electron optics and the design of electron optical devices. It presents this aspect of electron microscopy in considerable detail, providing a background for serious work in electron optics.

An extensive bibliography is given in the form of references at the ends of chapters. The book is well illustrated with drawings and photographs. Altogether, the authors have succeeded in writing an authoritative, and at the same time interesting and readable, treatise on this rapidly-growing field.

JOHN R. LOOFBOUROW

SOUTH OF THE SAHARA. *By Attilio Gatti. Robert M. McBride & Company, New York.* $3.00. 266 pp.; 32 plates. 1945.

Gatti has written an absorbing account of his radio broadcasting safari through central and south Africa, a book that is hard to lay down until it is finished. There is little scientifically new in it, either of anthropology or natural history, but Gatti is no mean teller of tales. (One suspects that, like most such, he is not above stretching a point, here and there.) Whether fishing with the Wagenia at Stanley Falls or watching the dances of the "gourd-headed" Mangbetus and their taming of young African elephants; whether hunting the okapi or the bongo; whether winning the trust and confidence of the pygmies or visiting the hospitable, giant Watussi and their long-horned, sacred cattle, the interest never flags. The strangest stories of all are saved for the last chapters, which relate the story of a Kaffir "pythoness" and her understudy, with their mysterious oracular gifts in reading secrets, and healing blind, halt, and insane. The book is illustrated with an abundance of excellent photographs taken by the author.

BENTLEY GLASS

LET'S FIND OUT: *A Picture Science Book. By Nina and Herman Schneider; pictures by Jeanne Bendick. William R. Scott, New York.* $1.25. 39 pp. 1946.

Clever little sketches and simple, ingenious experiments make this a fascinating book for the youngster. Heat, expansion and contraction, evaporation, steam, fog, rain, dew, and the properties of air are among the physical principles and phenomena with which a child can thus become familiar. Let us hope that the authors will next prepare a similar book dealing with biological facts and relationships. The present emphasis on experimental method and attitude in introducing science to children is a trend that is most encouraging.

KEYS TO NATURE'S SECRETS. *By Elizabeth Rider Montgomery; illustrations by Mary Stevens. Robert M. McBride & Company, New York.* $1.75. 64 pp. 1946.

This, like the preceding book, outlines and explains simple experiments for the child to perform. Those included here deal with light, expansion, air, musical sounds, water, levers, heat, and sound. The style is somewhat more didactic in tone, but the illustrations

are charming and the suggestiveness of the approach is to be commended. An error has been made in saying that "Liquids expand . . . as they freeze, and contract . . . as they become warmer," this being of course only a half-truth.

TUNGSTEN MINERALIZATION IN THE UNITED STATE
Geological Society of America Memoir 15.
By Paul F. Kerr. The Geological Society of Americ
New York. $2.50. x + 241 pp. + 23 plate
1946.